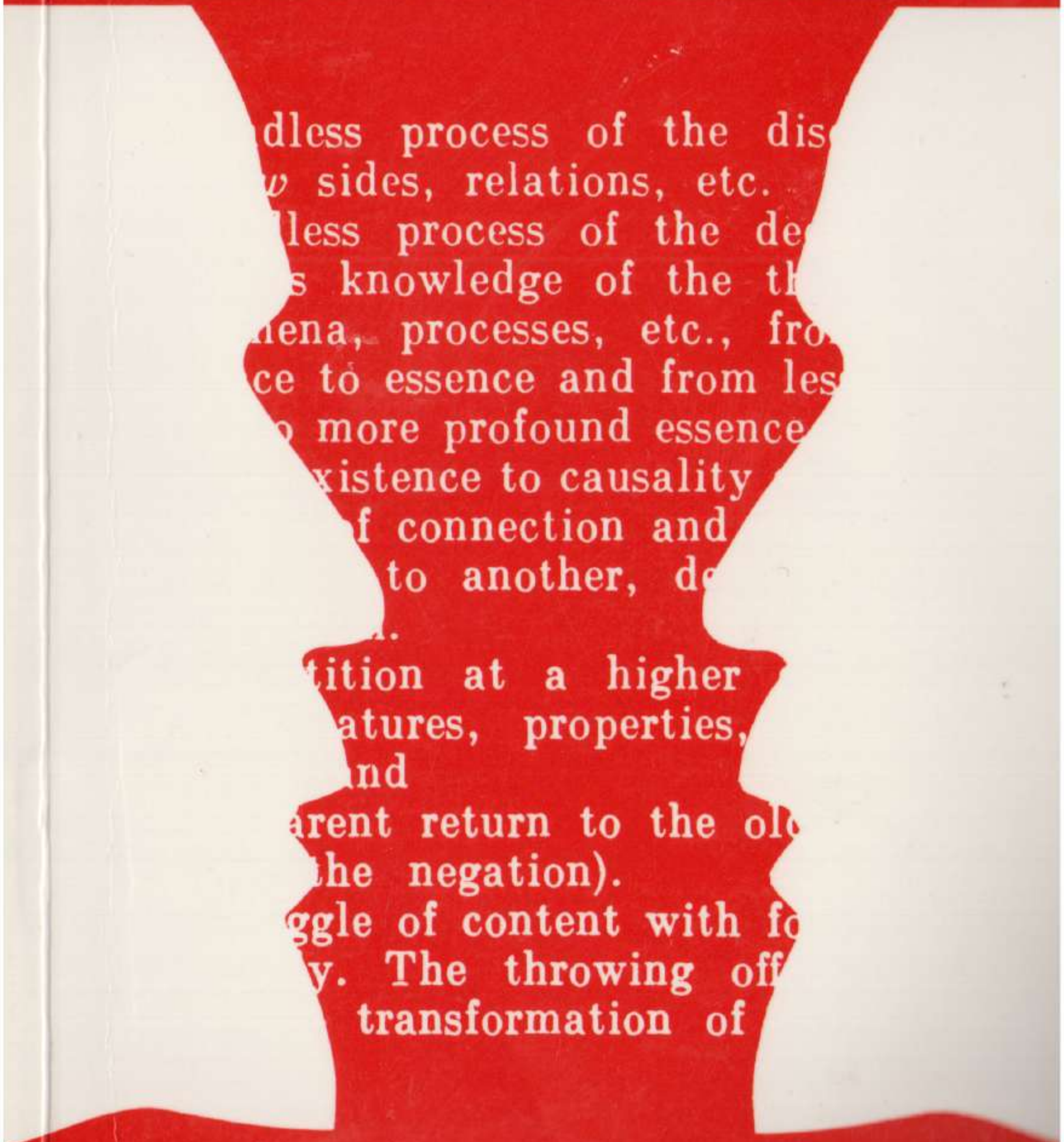
An Introduction to The Philosophy of Marxism

Part One

R. S. Baghavan

Preface by C. L. R. James



About the Author:

R.S. Bhagavan was born in 1927, and after a varied education came into the legal profession in 1956. He joined the Lanka Sama Samaja Party towards the end of 1942, when it was underground during the War, and became associated with all aspects of party activity, apart from public speaking. He edited the Sri Lankan editions of pamphlets by Rosa Luxemburg and Trotsky that were the only copies in print at that time. He is presently working on the second part of this book, which will cover the dialectical aspects of history.

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Part I

R.S. Baghavan

SOCIALIST PLATFORM

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Contents

Foreword

This is an admirable introduction. It introduces and at the same time it deals adequately with its subject. It has, however, one serious omission: it does not take its subject into distant seas as yet uncharted.

I am to do an introduction to it. I find that, in view of the tight comprehension of what I read, this is a task requiring space: to fill in gaps and expose unsuspected relations. This is beyond me and beyond my present perspectives. I shall therefore limit myself to presenting the subject as I see it.

Marxism is the climax of the thinking of western Europe. It is today an integral part of the thinking practice of western Europe. Neither of them, the thought of western Europe nor the Marxist complexity, can be understood unless seen in relation to each other.

Marxism is a climax. But when Marx began, western Europe had already reached ultimate stages in its different disciplines. Hegel had brought philosophy to a peak from which it was obvious there would be no new risings and plateaux. The business had reached its pinnacle and could no longer continue in those waters.

In the intellectual activity and discipline of history a climax had been reached with Michelet: history as a narrative of interesting events and dramatic personalities could go no further.

It is interesting to note that the criticism of Sainte-Beuve was recognised by the acute as the ultimate of a practical style of criticism. To the achievements of literary observation and analysis Victor Hugo had added poetry to scholarship and illumination to both. It is this finished achievement in various spheres that the youthful, educated and ambitious young Marx faced at the beginning of his entry into the literary and historical world.

As we can see today, and it would be rash to believe that Marx did not see it and was working by instinct: we can see today that literature could advance, not by going further along the road or

roads it was travelling, but by dramatic movement, what the master of phrase Hegel had designated as a 'leap'.

What is most striking today is the fact that Marx did not have to struggle and laboriously explore the ground in order finally to see a clear road. He was a very educated young man with a mastery of the classical languages and the literature and history of western Europe. He seemed to understand that there was no further development along the established lines and in the *Communist Manifesto* he said or rather he showed that he fully understood the new height that had been reached. Even to this day I must confess that no excitement in literature or history exceeds the excitement that attends a grasp of what was done in 1848.

Attempts have been made to show anticipations of the great discovery. I do not find them convincing. My belief is that Marx was already a master of all that literature and history and philosophy had achieved. Thus, for him, it was natural to leave it all behind and state the new requirements that the art demanded.

There have been many leaps from one stage to a higher stage in the progress of European history and literature. I don't believe that any of them in dramatic significance and result exceed what Marx did in 1848.

Let me explain what I am doing. I was requested to write a foreword to this *Introduction to the Philosophy of Marxism*. The *Introduction* is a very capable piece of work, being very much aware of the development of social theory and philosophy. There is an exceptional mastery of the details and a confidence which shows that the material has been mastered.

I am, however, personally very much aware of how easy it is to forget that Marxism, the insight into all kinds of intellectual achievements, is the result of a discipline, a construction by the human mind developed from contacts with the various events and historical development of the world outside it. Never must this be forgotten; in particular that the outside world is constantly changing and enlarging itself imposing similar consequences upon the intellectual discipline.

I end with what I began. The real beginning of the Marxist movement is in the writing of 1847 and 1848 and those are the direct result of the events of 1847 and 1848. Marx never went beyond that for the simple reason that it was impossible to do so.

C.L.R. James, March 1987

Chapter One

Preliminary

Neither Marx nor Engels claimed to be philosophers, though it is significant that Marx chose as the subject for his doctoral dissertation (1841) the philosophies of Democritus and Epicurus, the materialist atomists of Ancient Greece.*

Engels, who had, in 1842, published two critical articles about the philosophy of Schelling, when addressed as 'Doctor' and requested to contribute to a radical magazine, declined, protesting: 'I am only a merchant and a Royal Prussian artillerist.'[1]

Marx and Engels described their philosophical outlook as their 'method' and sometimes as 'the only scientific method', and did not give it a name. In 1886, after Marx's death, Engels wrote: '. . . this materialistic dialectic . . . has been our best working tool and our sharpest weapon. . .'[2]

The inverted phrase 'dialectical materialism' was coined by Plekhanov, who is also responsible for the statement that 'Marxism is an integral world outlook.'[3]

Philosophy, as Lenin emphasized, is a component part of Marxism.[4]

Marx fused the dialectical method of Hegel with the materialism

* It has been observed that Hegel passed lightly over the early materialists and that Marx made the first, and for a long time, the only, study of their ideas. Let us note, however, that after 1842 Marx lost interest in the publication of his thesis. It was published only in 1902, long after his death. In fact, the original has been lost, and what has been reproduced is an incomplete copy with corrections by Marx.[5]

culminating in the work of Feuerbach, and in so doing, made the greatest single philosophical contribution to human thought.

Only Marx could have done that, said Engels, his collaborator for forty years: 'Marx stood higher, saw further, and took a wider and quicker view than all the rest of us. Marx was a genius; we others were at best talented. Without him the theory would not be by far what it is today. It therefore rightly bears his name.'[6]

*

Through the years critics have accused Marx and Engels of not having set out their philosophical method in a self-contained work. Where, they demand, is *the* Book?[7]

Marx had hoped he could write one. In 1858, he wrote to Engels: 'If there should be time for such work again, I should greatly like to make accessible to the ordinary human intelligence. in two or three printer's sheets, what is rational in the method which Hegel discovered but at the same time enveloped in mysticism. . .'[8]

In 1876, writing to Joseph Dietzgen, he expressed the hope again: 'When I have shaken off the burden of my economic labours, I shall write a dialectic. The correct laws of the dialectic are already included in Hegel, albeit in mystical form. It is necessary to strip it of this form.'[9]

In 1873, Engels began working on a more, in fact, a very ambitious plan, which , unfortunately, he was compelled to drop in 1886. He left us fragments and unfinished drafts which were published under the title *Dialectics of Nature* only in 1925, thirty years after his death, and unfortunately, also, after the deaths of Plekhanov and Lenin.

*

Marx and Engels developed their philosophical method in works that were critical and polemical. Their joint works, *The Holy Family* (1844) and *The German Ideology* (1845-46)* were critical studies of post-Hegelian philosophical trends. Marx's *The Poverty of Philosophy* (1847) was a reply to Proudhon's *The Philosophy of Poverty* (1846) and may be justifiably re-titled *'Anti-Proudhon'* . In

* Published posthumously (1932). Admittedly written for 'self-clarification', Marx later wrote that, unable to find a publisher, they left the manuscript to the 'gnawing criticism of the mice.'[10] This was unfortunate, as here Marx and Engels used evolutionary ideas long before Darwin.

later years, Engels wrote *Anti-Duhring* (1887), again a polemical work.

The point critics avoid is that one has to have a philosophical position in order to polemicize against other schools of thought. As Antonio Labriola has reminded us, Marxism like any other idea or school of thought, did not drop, ready-made, from the sky.[11]

Marx himself observed, as early as 1842, that '. . . philosophers do not grow out of the soil like mushrooms, they are the product of their time, and of their people.'[12]
In another field of thought, Freud has remarked that '. . . complete theories do not fall from heaven.'[13]

As Engels noted, '. . . the science of thought is a historical science.'[14]

Marx developed his philosophical method in the late thirties and the early forties of the last century.

Hegel wrote under the intellectual impact of the great French Revolution. Marx began working at the time of the first independent stirrings of the working class and under the *impending* impact of the West European Revolution of 1848. Marxism was developed not only in critical conflict with traditional concepts and prevailing ideas, but also in *anticipation* of historical events.

Answering the critics, Lenin observed in his *Philosophical Notebooks* (1915): 'If Marx did not leave behind him a "Logic" (with a capital letter), he *did* leave the *logic* of *Capital,* and this ought to be utilized to the full in this question. In *Capital,* Marx applied to a single science*, logic, dialectics and the theory of knowledge of materialism (three words are not needed here: it is one and the same thing) which has taken everything valuable in Hegel and developed it further.'[15]

In his review of the German edition of the Marx-Engels *Correspondence* (1913) Lenin commented: 'If one were to attempt to define in a single word the focus, so to speak, of the whole correspondence, the central point at which the whole body of ideas expressed and discussed converges – that word would be *dialectics.*'[16]

It is worthwhile recalling here D'Arcy W. Thompson's observation that though the ancient Chinese never set out their chemistry, it is there—in their papers and ink, silk and porcelain, and their gun-powder.[17]

* The reference is to Hegel's *Science of Logic* (1812-1816)

Just as Sir Isaac Newton did not leave behind him a text-book of 'fluxions', but did give us a *Principia*, Marx and Engels have left us a rich heritage of *applied* dialectics.[18]

With materialism as their fundamental premise and dialectics as their method of investigation, they made brilliant analyses and *prognoses* of history and economics.

But the disadvantage is that a wide field of reading has to be covered before one gets a general idea of Marxist philosophical concepts.

It has been the practice of most writers on the subject of Marxist philosophy to follow the historical method of presentation. This method, which would be proper in a biographical or historical study, is hardly suitable for an introductory exposition of Marxist philosophy. The reader is not likely to be interested in following Marx and Engels through their polemics against various Nineteenth Century philosophers, most of whom have passed into obscurity and would not even be remembered today if not for Marx and Engels.

This introduction is didactic, the treatment is schematic and not historical. The laws of the Marxist method are presented and illustrated, for the sake of brevity, by a few examples. Dialectics being universal, there is no limit to examples. With a multiplicity of them, the reader would be unable to see the wood for the trees.*

It must also be noted that quotations are used here, not as invocations of authority — Marxism knows no sacred texts — but as finished expressions of the ideas to be conveyed. We might note with Trotsky that no one has presented Marxism better than Marx himself.[19]

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4. Lenin: *Three Sources and Three Component Parts of Marxism*, (1913).

* Or, as D'Arcy W. Thompson noted, in another connection, it would be like drawing water from a bottomless well. [17]

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Chapter 2

The Task Posed By History: Statement of the Problem

The echoes of the great French (bourgeois) Revolution (1789) had hardly died away when independent movement of the proletariat began. As Engels noted, the proletarian ideas of Gracchus Babeuf had already cast their 'fateful shadow' beside the bourgeois thought of Jean Jacques Rousseau.[1]

In 1831, an uprising took place in Lyons, France. Rallying under the slogan, 'Live Working or Die Fighting!', it was the first independent action of the working class in history.

In 1838, the English proletariat launched its Chartist movement, with less romantic and more down-to-earth slogans, one of which was: 'More Pigs, Less Parsons!'

In 1844, the Silesian weavers heralded the revolt of the German working class, a revolt, which, as Marx observed, contemporaneously, 'was directed not immediately against the King of Prussia, but against the bourgeoisie.'[2]

Everywhere in Western Europe, while industry was making feverish progress, the workers were raising their heads, outbreaks of the class struggle regularly disturbed the 'normal' functioning of national politics. Radical intellectuals, shadowed by insecurity, shifted from one philosophical position to another, sometimed flirted with shades of socialism, but generally ended up either in verbose

impotence or as shameless agents of the ruling classes.

The exceptions were few. In 1845, one of them, a twenty-seven year old German, already an exile in Belgium, wrote in his note-book: 'The philosophers have hitherto only *interpreted* the world in various ways; the task, however, is to *change* it.'[3]

The young man was Karl Marx, and the success with which he applied himself to the development of the theoretical basis and the practical aspects of this task is clearly indicated by the fact that his work has inspired gigantic social movements all the world over, while the bourgeoisie and its servants still direct towards his memory and his followers their unrelenting hatred.

*

'The philosophers have hitherto only *interpreted* the world in various ways; the task, however, is to *change* it.'

Let us note, however, that change occurs everywhere, and at all times, and also independently of the activity of men. All inorganic matter, once moulded into shape by nature or man, is subject to erosion and decay; birth and death is the basic rhythm of life.

The ancient Greek philosopher, Heraclitus of Ephesus, illustrated the universality of change with the aphorism that 'One cannot bathe in the same river *twice*'. Later, Cratylus, more expressively, emphasised that 'one cannot bathe in the same river *once*.'[4]

Society too changes, but imperceptibly most of the while. Our task is to participate in this change, to give it conscious and active direction.

It is, therefore, necessary to study the phenomena of change; the formulation of the laws of change in general will guide us in establishing the laws of social change.

And this is exactly what Marxist dialectics has done for us. As Engels noted: 'Dialectics is nothing more than the science of the general laws of motion and development in Nature, human society and thought.'[5]

Once we know the laws of change in human society, we can see where and how our activity may be integrated into the process of change taking place, for the reorganization of society is the crying need of our time.

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* As some wag has said, in half the world it is dangerous to be a Marxist, and in the other it is dangerous not to be.

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Chapter Three

Materialism

The basis of Marxist philosophy is materialism, and the essence of materialism is not at all difficult to understand and accept. Thomas Huxley once wrote: '. . . as long as we actually observe and think, we cannot possibly get away from materialism.'*[1] Marx quoted these words approvingly in a letter to Engels.

The word 'materialism' is easily understood, the more so because, in Marxist terminology, all non-materialist schools are termed 'idealist'.

Nikolai Bukharin drew a neat distinction between philosophical 'materialism' and 'idealism' and practical materialism and idealism. Marxists, he observed, are materialists in philosophy and idealists in practice.[3]

Philosophical materialism is not a crass self-dedication to the material things of life, but a point of view which asserts the primacy of matter.

Matter

Marxists proceed from the recognition of the world as a reality independent of human consciousness. And not Marxists only. This view was expounded by some ancient philosophers in China, India and Greece.

* In fairness to Thomas Huxley, we must mention that he described himself as an 'agnostic', a word which he coined.[2] (Agnosticism — no knowledge). Some of the non-Marxist writers quoted here were not consistent in their materialism.

When Europe awakened after the intellectual slumber of the Middle Ages, philosophers began once again to expound this fundamental idea, but it was Marx who gave it clear and finished expression.

In his *Materialism and Empirio-Criticism* (1908), Lenin defined 'matter' in the Marxist philosophical sense: 'Matter is a philosophical category designating the objective reality which is given to man by his sensations, and which is copied, photographed and reflected by our sensations, while existing independently of them.'[4]

He repeated: 'The one property of matter, the assertion of which defines philosophical materialism, is that of being an objective reality existing apart from our consciousness.'[5]

With the advance of scientific knowledge this position has been acknowledged by non-Marxist as well.

Anton Chekov, who was also a physician, observed: 'To forbid a man to follow the materialist line of thought is equivalent to forbidding him to seek truth. Outside matter, there is neither knowledge nor experience, and consequently there is no truth.'[6]

Albert Einstein has said: 'All physics is *realistic* in so far as it starts from the hypothesis of a reality independent of perception and thought.'[7] And again: 'Conviction that the external world exists independently of the observer investigating it constitutes the basis of the whole science of nature.'[8] Also: 'All knowledge of reality starts from experience and ends with it.'[9]

Another famous physicist, Max Planck, wrote: 'Belief in some sort of reality outside us. . . alone provides the necessary point of support in our aimless groping. . .'[10] And also: 'Theoretical physics assumes that events exist independently of our senses.'[11]

Still more forcefully, Planck expressed the concept of materialism in the form of *theorems*: 'Now there are two theorems that form together the cardinal hinge on which the whole structure of physical science turns. These theorems are: (1) *There is a real outer world which exists independently of our act of knowing*, and (2) *The real outer world is not directly knowable*.'[12]

The primacy of Matter

Scientific investigation has definitely and unquestionably established the fact that living matter originated from non-living matter. Though science has not yet determined the exact mechanism of the

process, the evolution of life from inorganic matter is an established fact. And life, at a certain stage of its evolution, produced the mind.

There have been three broad stages in evolution on Earth:

Non-Living Matter

Living Matter

Living and Thinking Matter.[13]

The process has taken ages; present estimates are:

Age of Earth:	c. 4,500,000,000 years.
Age of Life on Earth:	c.2,000,000,000 years.
Age of Man on Earth:	c.1,750,000 years.

The human mind then, has not existed from 'the beginning of time.' It is a product of nature and is conditioned by society.

Engels, summarizing Feuerbach, wrote: 'Matter is not a product of mind, mind itself is merely the highest product of matter.'[14]

Moreover, mind is not only a product of matter, it is also inseparable from matter. As early as 1651, Thomas Hobbes in his *Leviathan* declares: 'It is impossible to separate thought from matter that thinks.'[15]

This, in a nut-shell, is the meaning of the concept of the primacy of matter.*

Ideas are a Reflexion of Reality

Marx wrote: 'It is not the consciousness of men that determines their existence, but, on the contrary, their social existence that determines their consciousness.[17] And again: 'To me . . . the idea is nothing else than the material world reflected in the human mind and translated into forces of thought.'[18]

Lenin elaborated this view: 'This is materialism: matter acting upon our sense organs produces sensation. Sensation depends on the brain, nerves, retina, etc., i.e., on matter organized in a definite way. The existence of matter does not depend on sensation. Matter is primary. Sensation, thought, consciousness are the supreme products of matter organized in a particular way.'[19]

The process of scientific knowledge has shown the correctness of Marx and his materialist predecessors in maintaining that ideas are

* Friedrich Engels, in his experiments on hypnotism in 1843-44, empirically discovered the phenomenon of 'double memory' and thus knocked on the door finally opened to the world by Sigmund Freud, who proved, conclusively, that mind is, in part, independent of consciousness.[16]

shaped by the world of reality — by one's biological, historical, social, physical and psychological background.

Thomas Huxley commented: 'Surely, no one who is cognizant of the facts of the case, nowadays, doubts that the roots of psychology lie in the physiology of the nervous system.'[20]

Erwin Schrodinger, the famous physicist, has written: 'The first observations of nature by primitive man did not arise from any consciously constructed mental pattern. The image of nature which primitive man formed for himself emerged automatically, as it were, from the surrounding conditions, being determined by the biological situation, the necessity of bodily sustenance within the environment, and the whole interplay between bodily life and its vicissitudes on the one hand and the natural environment on the other.'[21]

Trotsky observed: 'The human mind is a product of the development of matter, and at the same time it is an instrument for the cognition of this matter; gradually it adjusts itself to its function, tries to overcome its limitations, creates ever new scientific methods, imagines ever more complex and exact instruments, checks its work again and yet again, step by step penetrates into previously unknown depths, changes our conceptions of matter, without, though, ever breaking away from this basis of all that exists.'[22]

The Fundamental Question of Philosophy: Idealism or Materialism?

Although this materialist-philosophical position was expounded by some thinkers, many other philosophers, both before and after Marx, held 'idealist' positions; they maintained that ideas were supreme and that reality was fashioned after the idea.

Rene Descartes* declared: 'I think, therefore I am.'[23]

Schopenhauer maintained: 'The world is my idea.'[24]

For Hegel, the world was the realization of 'the Absolute Idea.' 'There is nothing but the idea — the Idea is all reality.'**[25]

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* A devout believer, Descartes is sometimes classified as a 'dualist': (matter-spirit; reason-faith). In spite of his protests, his followers transformed his physics into a school of materialism. His contemporary Blaise Pascal complained: 'I cannot forgive Descartes; in all his philosophy he did his best to dispense with God. But he could not avoid making Him set the world in motion with a flip of His thumb; after that he had no more use for God.'[26] (See Marx and Engels: *The Holy Family*. Ch. VI.)

**Roy Pascal has remarked that this was a rather 'untheological name for God.'[27] It is interesting to compare this view with Radhakrishnan's interpretation of Hinduism: 'History is not a mere sequence of events, but it is the activity of the Idea or Spirit struggling to be born, endeavouring to realize itself through events.'[28]

In contrast, Marx declared: '. . . I am a materialist and Hegel is an idealist. Hegel's dialectic is the basic form of all dialectic, but only after it has been stripped of its mystical form, and it is precisely this which distinguishes my method.'[29]

In 1873, Marx repeated his position: 'My dialectic method is not only different from the Hegelian, but its direct opposite. To Hegel, the life-process of the human brain, i.e., the process of thinking, which under the name of the 'Idea', he even transforms into an independent subject, is the demiurgos of the real world, and the real world is only the external, phenomenal form of the 'Idea'. With me, on the contrary, the ideal is nothing else than the material world reflected by the human mind, and translated into forms of thought.'

And again, 'The mystification which the dialectic suffers in Hegel's hands, by no means prevents him from begin the first to present its general form of working in a comprehensive and conscious manner. With him it is standing on its head. It must be turned right side up again, if you would discover the rational kernel within the mystical shell.'[30]

The basic difference between idealism and materialism was defined by Engels: 'The great basic question of all philosophy, especially modern philosophy, is that concerning the relation of thinking to being. . . ideas to nature . . . which is primary, ideas or nature? The answer the philosophers gave to this question split them into two great camps. Those who asserted the primacy of ideas to nature and therefore in the final instance, assumed world creation in some form or another . . . comprised the camp of idealism. The others, who regarded nature as primary, belong to the various schools of materialism.'[31]

Trotsky summed up: 'The whole basic strength of Marx's method was his objective approach to economic phenomena, not from the subjective point of view of certain persons, but from the objective point of view of the development of society as a whole, just as an experimental scientist approaches a bee-hive or an ant-hill.

> 'For economic significance is what and how people act, not what they themselves think about their reactions. At the base of society is not religion and morality, but nature and labour. Marx's method is materialistic, because it proceeds from existence to consciousness, not the other way around. . .'[32]

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Chapter Four

Change is the only 'Absolute' Phenomenon

While recognizing the fundamental nature of inertia, change is the only 'absolute' phenomenon Marxists acknowledge.*

The realization that nothing is eternal, that everything is subject to change, has compelled the natural and social sciences to adopt an evolutionary approach to their subject matter.

As Newton observed, 'Nature delights in transformations.'[2]

In the *Introduction* to his *Dialectics of Nature*, Engels gives an account of the revolutionary impact the acceptance of this basic fact had on the sciences in the 18th and 19th Centuries.

Let us, following Engels, make a brief survey of the history of some of the sciences.

Cosmogony

In 1749, the French scholar, the Comte de Buffon, in his encyclopaedic *Natural History,* suggested a theory of cosmic evolution without an act of divine creation, and was, therefore, forced by the opposition of the Church, to recant his views.

But times changed, and the idea was hard to suppress. It was

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* The physicist Max Born begins his *The Restless Universe* (Blackie, 1935) by commenting that it is odd that there is a word for something that does not exist – 'Rest'. Contrasting the old concept that motion is a disturbance of the state of rest, Kirchoff said that, 'Rest is a special case of motion.' Engels hailed this statement and added that Kirchoff 'could not only calculate but think dialectically.'[1]

put forward again in 1755, in an anonymous pamphlet entitled *A General History of Nature*, published in Germany.*

In 1796, the French savant, Laplace, in his *Exposition of the System of the World*, attempted to place the theory on a scientific basis. And when Napoleon inquired why the Creator was not even mentioned, Laplace is said to have replied that he had 'no need of that Hypothesis.' [6]

Aeons ago, (between 10 to 13 thousand million years according to present estimates), the universe was a mass of very high temperature 'gas'. From this there condensed rapidly-spinning molten spheres – the stars. From one such star, our sun, smaller 'drops' were flung off to revolve round the mother sphere: these are the planets, the Earth among them.

Change, then, is the basic theme of cosmogony after Laplace: not gradual change, but change with explosions (the 'big bangs' of the cosmogonists), creation of planets, the flaring up and burning out of the stars.

The theory has been amplified, modified, challenged, contradicted and superseded. However, since Laplace, it has been incontestable that the universe has a history of birth, growth and decay. The old mythological concepts of a ready-made world, in which only regular seasonal variations occur, were shattered.

Geology

Under scientific investigation (Hutton, Cuvier, Lyell) the Earth's crust yielded its story. The continents and oceans have not been eternal. The cooling of the Earth's crust has been uneven; land masses were suddenly elevated; continents forced to drift apart, mountain ranges were pushed up and new oceans formed. Huge ice sheets, then advancing, now retreating, covered the Earth's surface for millenia.

The pioneer geologist, James Hutton of Scotland, in his *Theory of the Earth* (1785) said quite aptly that he could see 'no trace of a beginning and no prospect of an end.'[7]

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* It was discovered later, with the posthumous publication of the *Collected Works*, that the author was none other than Immanuel Kant. 'Give me matter,' he said boldly, though anonymously, 'and I shall give you a world.'[3] Earlier Rene Descartes had declared, 'Give me matter and motion, and I shall give you the Universe.' He maintained that physical facts could be explained by 'figures and motion', in modern terminology, 'configurations and motion,' or more exactly the initial conditions and the laws of motion.[4] Two hundred years later, James Clerk Maxwell repeated: '. . . one material system can differ from another only in the configuration and motion which it has at a given moment. . .' [5]

Biology

In 1859 Charles Darwin published *The Origin of Species*, which not only provided convincing evidence for the earlier conjectures of the evolution of animals and plants, but also advanced new, revolutionary concepts of evolution.

Through the ages, complex organisms have developed from the simplest micro-organisms. Variation, specialization and adaptation to environmental conditions produced the distinguishing characteristics of the species as we know them.

Darwin's explanation of the mechanism of the process, by the principles of 'natural' and 'sexual selection', the 'survival of the fittest' in 'the struggle for existence', is now seen to be insufficient to account for the evolution of species and has been supplemented and modified by further investigation, discoveries and theories. But, after Darwin, the evolution of living beings has to be an accepted fact. Not only is there a geographical distribution of animals and plants, there has also been a slow, but uneven, development in time. The belief in the fixity of species received a mortal blow.

Anthropology

When the Europeans set out on their voyages of discovery, they found many lands populated by peoples with other customs and cultures, and at other levels of civilization.

In 1861, Bachofen, with his study of *Mother Right*, pioneered the study of the history of the family. In 1877, Morgan published his *Ancient Society*, providing clear evidence of the evolution of the family. Marx and Engels immediately appreciated the work of Morgan and developed a theory of the evolution of the family and studied the underlying social forces and the unfolding of family forms.[8]

History

Society changes, but for the large part, imperceptibly, that few noticed the changes or cared. Conservative people at all times accepted history as a divinely-inspired achievement of a perfect society, that is, the existing one. Wars and revolutions were viewed as unfortunate 'disturbances' of the smooth functioning of 'normal' social life.

But to Marx who discovered the laws of social change, wars and revolutions, and the perpetually erupting class struggle in 'peace' time were integral parts of the process of world history. He predicted that in the further development, a socialist society would replace the capitalist, and that 'the *prehistory* of human society would accordingly close with this social formation.'[9]

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Alas, for the smugness of the philosophers of the status-quo, scientific investigation showed that change had ravaged everything that they had considered fixed and unchanging and handed down from time immemorial. And science, every branch of it, was forced to recognize the importance of the consideration of evolution, development and change.

We can agree, then, with Engels, that, '. . . the world is not to be comprehended as a complex of ready-made *things*, but as a complex of *processes*, in which the apparently stable things, no less than their mind images in our heads (the concepts), go through an uninterrupted process of coming into being and passing away, in which in spite of all seeming accidents and of all temporary retrogressions, a progressive development asserts itself.'[10]

References

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2. Newton quoted in D'Arcy W. Thompson *On Growth and Form* Cambridge University Press. 1942. p. 1030.
3. Quoted by Gamow: *The Creation of the Universe*.
4. See L. de Broglie: *Matter and Light* p. 237.
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6. Laplace: See Engels: *Dialectics of Nature* p. 203. For background material: M. Kline: *Mathematics in European Civilization*, O.U.P., N.Y. 1964 Ch. XIV to XVIII.
7. Hutton quoted in W.L. Stokes: *Essentials of Earth History* Prentice Hall. 1960. p. 37.
8. See Engels: *The Origin of the Family*. 1884.
9. Marx: *Introduction* to *The Critique*. p. 20.
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Chapter Five

Some Fundamental Principles

It was Hegel who drew the distinction between *dialectical* thinking and *metaphysical** thinking.

The following principles, *inter alia,* distinguish *dialectical* from *metaphysical* thought.

1. Phenomena are Studied in their Contexts of Space and Time

'An event', (say, accident), 'occurred', is a statement that is incomplete and, therefore, meaningless. The statement has meaning only when the place and time are specified.

Every farmer knows that the success of his crop depends not only on the quality of his seed but also on the nature of the soil, and of course, the weather. Every child knows that wild plants differ, at least in size, from the same plants grown in pots.

Charles Darwin, in 1876, confessed: 'In my opinion, the greatest error which I have committed has been not allowing sufficient weight to the direct action of the environments. . .'[2]

The famous American plant-developer, Luther Burbank, observed: 'A fact is relative, and if it is placed out of its relative position, it apparently is not a fact, often.'[3]

As early as 1842, Marx pointed out that: 'The correct theory must be made clear and developed within the concrete conditions

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* *Metaphysics* – After-Physics – was the title given to Aristotle's book succeeding the *Physics*.[1]

and on the basis of the existing state of things.'[4]

Criticising Proudhon, Marx remarked that '. . . his history proceeds in the misty realm of imagination and rises far above space and time,' and emphasized that all social forces are 'historical and transitory.'[5]

'A negro is a negro,' Marx pointed out, 'only in certain conditions does he become a slave.'[6] And again, 'Hunger is hunger; but the hunger that is satisfied with cooked meat eaten with fork and knife is a different kind of hunger from the one that devours raw meat with the aid of hands, nails and teeth.'[7]

In 1877, Marx observed: 'Thus events strikingly analogous but taking place in different historical conditions lead to totally different results.'[8]

Commenting on the 'absolute truth' of the Utopian Socialists, Engels wrote: 'And as absolute truth is independent of time, space and of the historical development of man, it is a mere accident when and where it was discovered.'[9]

In criticising Feuerbach's theory of morals, Engels commented: 'It is designed to suit all periods, all peoples and all conditions, and precisely for that reason it is never and nowhere applicable.'[10]

The idea is already there in Hegel, who wrote: 'Space and time are filled with matter. . . Just as there is no motion without matter, so there is no matter without motion. . .'[11]

In sum, as Engels said: '. . . the basic forms of all being are space and time, and being out of time is just as gross an absurdity as being out of space. . .'[12]

In 1908, Lenin repeated: 'There is nothing in the world but matter and motion, and matter in motion cannot move otherwise than in space and time. . .'[13]

In the same year, Herman Minkowski, who developed the mathematics of Einstein's 'Theory of Relativity' observed: 'Nobody has ever noticed a place except at a time, or a time except at a place.'[14]

Juxtaposing phenomena out of their contexts produces anachronisms or absurdities, a method that was probably first exploited by Cervantes in his celebrated novel (1604). Marx commented: 'Don Quixote long ago paid the penalty for wrongly imagining that knight errantry was compatible with all economic forms of society.'[15]

Mark Twain used the reverse technique to poke fun at mediaeval England in his *A Connecticut Yankee in King Arthur's Court* (1889).

2. Phenomena are Studied in their Inter-Connections with one another

Just as a phenomenon cannot be isolated from its context of space and time, one phenomenon cannot be isolated from another.

Goethe once observed: 'In nature we never see anything isolated, but everything in connection with something else which is before it, beside it, under it, and over it.'[16]

Marx said that: 'Circumstances make men as much as men make circumstances.'[17] And again; 'By acting on nature outside himself, man changes his own nature.'[18]

In 1853, commenting on the events in China, Marx wrote: 'The next uprising of the people of Europe may depend more probably on what is now passing in the Celestial Empire. . .'[19]

Marx noted: '. . . interaction between the various aspects. . . takes place in every organic unity. . .'[20]

Engels wrote: 'The whole of nature accessible to us forms a system, an inter-connected totality of bodies. . . they react on one another.'[21] He emphasized: 'Dialectics is the science of inter-connections'.[22] And again: 'Reciprocal action is the first thing that we encounter when we consider matter in motion. . .'[23] He pointed out: 'The essential element of life is the continual inter-change with the natural environment.'[24]

Franz Mehring wrote: 'Historical materialism is no closed system crowned with an ultimate truth; it is a scientific method for the investigation of human development. It begins with the indisputable fact that men live not only in nature, but also in society. There are no such things as isolated men; every man, who by accident is left outside human society, quickly starves and dies.[25]

'The history of any people is the history of its neighbours,' observed the historian Rudolph Goldscheid.[26]

Engels in his *Introduction* to Marx's *Class Struggle in France* commented on the irony of history in that Bismarck was instrumental in creating the German Empire and the French Republic.

Trotsky advised revolutionaries to study the history of America and England together, because '. . . the United States and Great

Britain must be regarded as twin stars, one of which grows dim the more rapidly as the brilliancy of the other increases.'[27]

We may add that the study of the history of England also necessitates the study of the history of her former Empire, especially India.

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Scientific investigation has provided us with a number of vivid illustrations of this principle.

Sir Isaac Newton taught us that all matter interacts gravitationally.

There is interaction, even as the ancients (Thales) knew, between electrical charges and also between magnetic poles.

Erwin Schrodinger emphasized: '. . . physical action is always *inter*-action, it always *is* mutual. . .'[28]

The work of Oersted (1820), Henry (1830) and Faraday (1831) in the early years of the last century established the laws of inter-action of magnetic fields, electric currents and mechanical forces, and made possible the electric motor and the dynamo which opened up vast new resources for mankind.*

In 1864, James Clerk Maxwell, by mathematical analysis of these inter-actions and a synthesis of the existing knowledge of electro-magnetic phenomena, predicted the existence of a broad spectrum of electro-magnetic waves of which visible light is only a small part.

In 1888, Heinrich Hertz detected radio waves in a part of the non-visible spectrum and laid the foundation for a major break-through in communication.

In 1895, Roentgen discovered 'X-rays' in another part of the electro-magnetic spectrum.

The whole of chemistry is the study of the interaction of the elements and their compounds. Only a few elements like gold, sulphur and carbon are found in their pure form.

The inert gases went undetected for a long time, precisely because they do not interact with other elements. And it is a significant fact that the first of them to be detected was observed by

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*C.P. Steinmetz, in the early years of this century calculated that a single electric turbine of General Electric produced more power than the entire slave population of the United States at the time of the Emancipation.

spectroscopy not on earth but in the sun (Janssen, 1868) and aptly named helium* by Frankland and Lockyer. It was 1895 when helium was detected on earth by the experimental ingenuity of William Ramsay.

The other inert gases were tracked down in rapid succession. Rayleigh and Ramsay isolated argon (the 'idle' and 'inactive') in 1895; Ramsay and Travers isolated neon (the 'new'), krypton (the 'hidden') and xenon (the 'stranger') in 1898, and finally, in 1900, Ramsay and Dorn identified radium emanation, radon, the last of the inert gases. Despite their usefulness and importance in physics and industry, none of these gases has a 'chemistry'.

And when in 1896, Henri Becquerel discovered a phenomenon, which Madame Curie a short while later termed 'radio-activity', science found a door to enter the sub-atomic world. It was soon found that the fundamental characteristic of the'elementary' particles is that they interact: they attract, repel, fuse, annihilate each other, and sometimes split up or transform themselves.

3. Phenomena are Studied in the Process of their Development

To ignore change, the ancients warned us, is to ignore Nature. Centuries ago, Heraclitus taught us that '. . . to understand Nature means to represent it as a process.'[29]

A study of phenomena in the process of change is far more instructive and rewarding than a study of the static state.

The history of geometry illustrates the value of a dynamical study of space. Plato, who encouraged the study of geometry is said to have had inscribed at the entrance to his Academy the words: 'Let him not enter here who, knows no Geometry!'** In his over-enthusiasm, however, he placed the study of the subject in a straight-jacket by insisting that the onlt instruments permissible were an unmarked straight-edge and a pair of compasses.

Euclid (c. 250 B.C.) with brilliant logic systematized all the available knowledge of geometry in his monumental *Elements,* but succeeded, as we see it today, in producing only a still-life. Time,

* From *Helios*, Greek for Sun. The spectroscope was first used for the study of the sun by a French expedition to South India during the solar eclipse of 1868.

**A more accurate, if uncharitable, translation reads: 'A credit in mathematics is required.'[30]

and the position of geometrical figures has no significance in his system. (Mirror images, which are not identical, were to Euclid, 'congruent.')

Archimedes, Apollonius and their contemporaries tried to introduce time and movement into geometry, but, handicapped by a lack of a suitable number notation and mathematical symbolism, could not make much progress. Europe had to wait for centuries until the Arabs brought the Hindu number system and Arabic algebra and trigonometry to fertilize the mathematical knowledge of antiquity.

The concept of movement in geometry ('locus') was re-introduced by Bishop Oresme (c. 1360 as 'forma'), and two millenia after Euclid, Rene Descartes published his *La Geometrie* (1637) in which he fused two streams of mathematics and applied algebraic methods to geometrical problems, and geometrical methods to algebraic problems.

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Marx accepted this principle even while a student. In 1837 he wrote to his father: '. . . the object itself must be studied in its development. . . '[31]

In his *Afterword* to the Second Edition of *Capital* (1873), Marx made a very important observation: 'Of course, the method of presentation must differ from that of inquiry. The latter must appropriate the material in detail, to analyse its different forms of development, to trace out their inner connection. Only after this work is done, can the actual movement be adequately described. If this is done successfully, if the life of the subject matter is ideally reflected as in a mirror, then it may appear as if we had before us a mere a priori construction.'[32]

Engels warned us that 'the world is not to be comprehended as a complex of ready-made *things* but as a complex of *processes* . . . '[33]

Dialectics, Engels said: 'grasps things and their images, ideas, essentially in their interconnections, in their sequence, their movement, their birth and death.'[34]

Trotsky commented: 'Marxist thought is dialectical; it considers all phenomena in their development, in their transition from one state to another. . . '[35]

And again: 'Marx's method is dialectical, because it regards

both nature and society as they evolve, and evolution itself as the constant struggle of conflicting forces. . .'[36]

In his last polemic against the opponents of dialectics, Trotsky observed: 'Vulgar thought operates with such concepts as capitalism, morals, freedom, workers' state, etc., as fixed abstractions, presuming that capitalism is equal to capitalism, morals are equal to morals, etc. Dialectical materialism analyses all things and phenomena in their continuous change, while determining in the material conditions of those changes that critical limit beyond which "A" ceases to be "A", a worker's state ceases to be a worker's state.'

'The fundamental flaw of vulgar thought lies in the fact that it wishes to content itself with motionless imprints of a reality which consists of eternal motion. Dialectical thinking gives to concepts, by means of closer approximations, corrections, concretizations, a richness of content and flexibility; I would even say a succulence which to a certain extent brings them closer to living phenomena. Not capitalism in general, but a given capitalism in a given state of development. Not a workers' state in general, but a given workers' state in a backward country in an imperialist encirclement, etc.'

'Dialectical thinking is related to vulgar thinking in the same way that a motion picture is related to a still photograph. The motion picture does not outlaw the still photograph but combines a series of them according to the laws of motion . . .'[37]

4. Dialectics Studies Particular Aspects of a Phenomenon Without Losing Sight of its Generality — It Analyses and Synthesises

It is proverbial, that the whole is more than the mere sum of its parts. An animal or plant is more than a mere collection or arrangement of cells.[38]. A poem is more than a collection of words. A painting is more than a collection of pigments.[39]. Society is more than a collection of individuals.[40] The world economy is not a mere sum of national economies.[41] Examples may be continued without end.

Professor Koffka said, rather forcefully, that the whole is *something other than* the sum of its parts.[42]

There is a lot of dialectical wisdom in the ancient tale of the blind men who sought to perceive the shape of an elephant by feeling

the part nearest each of them — unable to synthesize their observations, they fell out among themselves.

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Scientific investigation has scored great successes by using the method of analysis, abstraction and isolation, by studying certain aspects of a phenomenon, while eliminating all else that is, for the immediate purpose, irrelevant.

In his *Discourse on Method (1637)*, René Descartes advised us: '. . . to divide each of the difficulties under examination into as many parts as possible, and to proceed . . . always from the simplest and easiest to the more complex . . .'[43]

S.I. Vavilov observed in his study of *Isaac Newton*: 'Many stages in the history of science have been accompanied by an intentional disregard – temporarily – of a group of facts and whole spheres of phenomena that complicate a problem.'[44]

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In 1583, Galileo Galilei, then only nineteen years old, while gazing at an ornate chandelier swinging gently during a service in the Cathedral of Pisa, saw in the complex system just three things: the point of suspension, the length of the system and the weight attached to the end of it. This was, in essence, a plumb-line, an instrument known from ancient times. It required the genius of Galileo, timing the swings by his pulse beat, to see in an oscillating plumb-line the dynamical proportions of the pendulum. By this process of abstraction he was able to discover the principle of regular ('isochronous') oscillations, a discovery which provided a theory for accurate mechanical time-keeping and laid the foundation for a new era in the history of mankind.*

Though the breaking up of a complex system into simpler parts helps the study of a phenomenon, it is by no means all there is to the study of the original complexity.

In his *Revolutions*, Copernicus warned us: 'The scientist who would examine the various phenomena individually, without regard to the order and close dependency among them, might be compared with a man who would borrow fragments, such as hands, feet, and other parts of the body, which, though truly painted by a master's

* The pendulum clock was invented by Christian Huyghens in 1657.

hand, represent different bodies, and who would attempt now to put these heteroclitic fragments together, which do not fit one to the other, and the composition of which would rather yield the picture of a monster than that of a human body.'[45].

Hegel pointed out the same: 'Only in their connection are the individual limbs of the body what they are. A hand, separated from the body, is a hand only in name . . .'[46]

Engels wrote: 'In order to understand the separate phenomena, we have to tear them out of the general inter-connection and consider them in isolation, and *then* the changing motions appear one as the cause and the other as effect.'[47]*

Lenin observed: 'The splitting of a single whole and the cognition of its contradictory parts. . . is the essence of dialectics, and again, that one of 'the elements of dialectics' is 'the union of analysis and synthesis.'[48]

Dialectics studies the all-sidedness, the complexity of a phenomenon, the richness of its content. It sees variety in the generality and generality in the variety, analyses and synthesises.**

5. 'Conceptual Totality' Must be Distinguished from 'Concrete Totality'

In an unfinished draft (1857-8) (now published as an appendix to *The Critique*) Marx left us a section entitled *On the Method of Political Economy*, in which he pointed out that political economy, like the other sciences, starts out by analysis and reconstructs a scientific system by synthesis. 'The latter is obviously the correct method. The concrete concept is concrete because it is a system of many definitions, thus representing the unity of diverse aspects.'

He drew the very important distinction between 'concrete totality' and 'conceptual totality.'[49]

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The Oxford mathematician, the Rev. Charles Dodgson, writing under the pseudonym Lewis Carroll, has left us a picturesque

* See also Engels' criticism of Bacon and Locke in *Anti-Duhring* (Introduction, General I). (Moscow Edition, 1962, p. 34).

**Lenin dealt with this point in his speech *Once Again on the Trade Union Question* (25th January 1921). This speech has not been quoted here; it is readily avalable and is recommended in its entirety. (See *Collected Works* XXXII, pp. 93-94).

description of a concept in *Alice in Wonderland*(1865): In Chapter I, Alice 'tried to fancy what the flame of a candle looks like after the candle is blown out, for she could not remember ever having seen such a thing. . .'

And still more graphically in Chapter VI, the Cheshire cat 'vanished quite slowly, beginning with the end of the tail, and ending with the grin, which remained some time after the rest of it had gone.'

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The classic case of a conceptual system, one which was unchallenged for more than two millenia, is that of Euclidean geometry.

Euclid (c. 250 B.C.), following his predecessors, beginning with Thales, used a set of abstractions — non-dimensional points, uni-dimensional lines, two-dimensional planes and three-dimensional space, to give us in his *Elements* a grand conceptual system of geometry.*

In other fields of science, the creation of conceptual systems proved to be more complicated.

In 1846, Michael Faraday wrote to a friend: '. . . the view which I am so bold as to put forth. . . endeavours to dismiss the ether, but not the vibrations.'[51]

James Clerk Maxwell, in his inaugural lecture as Cavendish Professor (1871) complained: '. . . wrenching the mind away from the symbols to the objects and back from the objects to the symbols, that is the price we have to pay. . .'[52]

Maxwell scored great successes in theoretical physics, but did not succeed in dismissing the ether. As is well known, the ether concept was dismissed only in 1905, after Einstein's theory of 'Relativity'.

Writing in recent times, the great naturalist D'Arcy W.

* This method has been used in geometrical optics (where light rays are represented by straight lines) and in graphical statics (where forces are reduced to straight lines) with great, even if limited, success. Sadi Carnot worked with a conceptual abstraction of an 'ideal engine'. (See Engels' comments in *Dialectics of Nature* p. 232.) Molecular physics used the concept of an 'ideal gas'. Kelvin used the concept of an 'ideal' thermometer independent of a thermometric substance. Morris Kline has aptly described the procedure as 'keeping the grin and letting the cat go.'[54]

Thompson advised biologists 'to learn from the mathematicians to eliminate and to discard; to keep the type in mind and leave the single case, with all its accidents alone. . .'[53]

6. The Results of an Investigation Depend on the Standpoint of the Investigator

It is common experience that warm feels cold if one's hand has earlier been immersed in hot water; and that cold water feels warm if one's hand has earlier been in iced water.

'The sun rises in the East and sets in the West,' is an observation true enough in the tropic and temperate zones. However, in the Arctic and Antarctic Circles, for some months the sun never sets and for other months it never rises.

For the pioneer explorers who sailed south down the west coast of Africa, (Phoenicians, according to Herodotus), the sun rose on the left. The day it rose from the right, they realized that they had rounded a cape.

Rain drops which are seen to fall vertically by an observer at rest, appear to slant towards a moving observer.

Let us view, with Einstein, the fall of a stone from a moving train. If we are in the train, the stone appears to fall vertically downwards. But from the embankment the stone is seen to move in a curve produced by the effect of two motions — the forward motion of the train and the downward motion to earth. It is a basic idea of Einstein's theory of 'Relativity' that all measurements are made, not in the abstract 'absolute', but in a given real 'framework' of space and time.[55]

The 'Doppler Effect', as an acoustic phenomenon, will be familiar to all keen observers: the pitch of a note drops as the source of the sound – a whistling train or a whining jet – approaches, passes and recedes.

Doppler first predicted the effects, in 1842, for optical phenomena. If the source of light (a star, for example) is moving away from us, the spectrum shifts to the red end; if towards us, to the blue end. The observations of this effect led to Hubble's theory (1925) of an 'expanding universe'.[56]

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Let us now go back to a classic case. To an observer on earth, the

sun, moon, planets and the stars appear to move round the Earth. This geo-centric system, associated with the name of Ptolemy, led to complications in the calculation of planetary orbits. Anyone who has tried to unravel the mysteries of ancient and mediaeval astronomy can appreciate the irreverent remark attributed to King Alfonso (the 'Wise') of Castille, that had he been present at the Creation, he would have suggested something simpler.

Copernicus separated the daily rotations of the Earth on its axis and the annual revolutions round the sun. He shifted the axis of the solar system from the Earth to the sun and thus not only provided an explanation of the observed retrograde motion of the 'outer planets'*, but, more important, *he discovered the sixth planet* – our own Earth. His *Revolutions* (1543) gave astronomy – and mankind – a new perspective and laid the foundations for the later work of Galileo, Kepler and Newton.** It marked, as Engels noted, natural science's 'declaration of independence' from theology.[57]

Marx explained that his 'standpoint' was one 'from which the evolution of the economic formation of society is viewed as a process of natural history'.[58] Marxists view history from the standpoint of the interests of humanity, that is, of the revolutionary establishment of a socialist society.

Lenin emphasized that: 'There can be no "impartial" social science in a society based on class struggle.'[59]

It was this standpoint and perspective which enabled Marx and Engels to see far into the 20th Century. As Rosa Luxemburg observed, 'their prophetic eyes' saw events as they lay 'in the womb of the future'.[60]***

'Assuredly,' wrote Trotsky of the *Communist Manifesto*, 'the young authors (Marx was 29, Engels 27) were able to look further

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* In his time, Mars, Jupiter and Saturn.

**Heraclides of Pontus, in the 3rd Century B.C., had declared that the Earth rotates on its axis. Aristarchus of Samos is credited with the idea of the revolution of the Earth round the sun, and is called the 'Copernicus of Antiquity'. The encyclopaedic Leonardo da Vinci had also noted this before Copernicus.

***Their scientific outlook and political persepective made Marx and Engels appear as prophets. For Engel's minor prophecies see his remarks about Frederick William II in *Collected Works II*. Marx ended his *The Eighteenth Brumaire*, (1851-52) with the prediction '. . . the bronze statue of Napoleon will crash from the top of the Vendôme column.' This became literally true on the 16th of May 1871, when the Paris Communards pulled the statue down. Eight days before the debacle of Sedan, Engels, in one of a series of unsigned articles in the *Pall Mall Gazette*, predicted the defeat of Napoleon III, and earned the nickname 'General'. Lenin in his *Prophetic words* (1918) comments that Engels was able to forsee events that would take place a quarter of a century after his death.

into the future than anyone before them, and perhaps anyone since them.'[61] If they were over-optimistic as to the tempo of revolutionary events, that was because they 'stood on a high mountain, and distances seemed shorter to them.'[62]

7. Scientific Laws and Theories are Limited Generalizations

Once facts and observations have been accumulated, their interconnections are studied, observed regularities – 'laws' – are noted and a generalization which fits the facts – a 'theory' – is formulated.

The facts must be arranged in a 'pattern'. As Henri Poincaré pointed out, 'Science is built up of facts, as a house is built up of stones; but an accumulation of facts is no more a science than a heap of stones is a house.'[63]

The first 'laws' as observed regularities were probably discovered in heavenly motions by the shepherds of ancient Chaldea.

Sometimes the regularities of Nature force themselves upon us. When Charles Darwin recorded his extensive observations in his note-books, he found that the facts began 'to group themselves clearly under sub-laws.'[64]

It would be a serious mistake, however, to apply these laws outside their range of validity, that is, to 'extrapolate' them without justification.

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As long as we do not travel far from our homes, we may take it that the earth is flat. People lived happily for centuries – and many still do – without suspecting that this view is a very limited, a pedestrian truth.[65]

For the purpose of inter-continental sea travel, however, it was found necessary to take into consideration the fact that Earth is a sphere. What was a matter of scientific curiosity and philosophical speculation on the part of the Ancient Greeks*, became a vital issue

* Thales, the first Western philosopher thought that the Earth was a flat *disc*. (This, as we can well imagine, sufficed for his 'explanation' of eclipses.) For Pythagoras, the Earth was a sphere, because, 'mathematically', the sphere was a perfect body. Thales was probably the first person to use the method of *indirect* measurement. He *calculated* the height of a pyramid by *measuring* its shadow; he also estimated the distance of ships at sea. Eratosthenes (c. 250 B.C.) extended Thales' method. He made the *first* bold estimate of the circumference of the Earth by measuring a small corner of Egypt; terrestrial distances were calculated from measurements of stellar positions![66]

in its historical context when Christopher Columbus proposed (c. 1492) to find a westward sea route to India.

For more accurate purposes – jet-flight and rocketry – we have to make allowances for the fact that the Earth is an oblate 'spheroid', bulging a little at the equator and a little flat at the poles. This fact was predicted, theoretically, by Newton (*Principia* 1686), proved experimentally by Huyghens, and recorded by survey by the French after the Revolution.

With the realization that the Earth is spherical, up and down lose their 'absolute' meaning, and the vertical, determined by a plumb-line or the direction of a falling body, becomes limited to a 'local truth'.

The old saying, 'What goes up must come down,' was true in practice only till the 4th of October 1957, on which day a rocket leaving the Earth at a velocity of about 8 km/sec. put into orbit the first artificial Earth satellite – The *Sputnik*.

The Aristotelean maxim that 'Nature abhors a vacuum', which was used to explain the action of water pumps, is true, as Galileo acidly observed, only to a height of 34 feet of water.*

The Euclidean lemma that the shortest distance between two points is a straight line, is true only for a plane surface. On a spherical surface, it is the arc of a great circle.**

In 1639, two years after the mathematical revolution of Rene Descartes, another Frenchman Girard Desargues wrote a *Projective Geometry*. Basing himself on the 'eye-view' requirements of painters and map-makers, he introduced non-Euclidean concepts of parallel lines meeting at infinity, etc. But habits of thought die hard, even in abstract subjects like geometry. Desargues was ignored, all his books were lost and his ideas came into their own only two hundred years later from a manuscript copy made by one of his contemporaries.[67]

Euclid's 'Fifth Postulate', (Playfair's axiom as it is sometimes called), that through a point only one straight line can be drawn parallel to another, was challenged by Bolyai of Hungary (1823),

* In 1643, Galileo's pupil, Evangelista Torricelli explained the action of water pumps by the pressure of the atmosphere, and in 1651, Otto von Guericke demonstrated this by a series of dramatic experiments.

** 'Time-wise for 'free fall', the shortest distance, the curve of quickest descent ('brachistochrone') is the arc of a cycloid, discovered by Johann Bernouilli in 1696.[69]

Lobachevsky of Russia (1826), and the Germans Gauss (1831) and Riemann (1854). They created new conceptual systems of geometry without this axiom, and opened up new perspectives in geometry and physics. Zeldovich has aptly described their work as 'the lightning flashes that preceded the thunderbolt of Einstein's "Theory of Relativity." '[68]

In the early years of this century, it was found that Euclidean geometry was inadequate to describe the physical space required by Einstein's 'Theory of Relativity' (1905), and, in 1908, Herman Minkowski had to revive the concepts of non-Euclidean space and introduce a four-dimensional space-time continuum.[70] Some scientists sighed nostalgically, that Euclid has been 'so psychologically satisfactory.'

In another field of investigation, statistics, Willard Gibbs of America found that he had to use the concept of 'hyper-space' (1901).*

From a study of nature, D'Arcy W. Thompson makes an interesting remark that the bees' world may be four-dimensional.[71]

As Steinmetz has observed, all mathematical truths are relative truths.[72]**

Perhaps the first mathematician who drew attention to this fact Archbishop Nicholas Cusanus, who, in the 15th Century, pointed out that rules for finite quantities are invalid for infinites, and, as we may note by extension, for infinitesimals.[73]***

In *Anti-Duhring*, Engels draws attention to the fact that Boyle's law (connecting the volume and pressure of a gas) had a limited range of validity.[77] In his *Dialectics of Nature*, he points out that as there is no water on the Sun or Moon, the law of the boiling of water is merely local, historical, and not eternal.[78]

Descartes, who, in the 19th century, unwittingly laid the foundation for French materialism, gave us a picture of the animal

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* This concept can also arise from elementary algebraic considerations.[74]

**To give just one example: 'Euler's formula for prime numbers, $x^2 - x + 41$,is true for $x = 0, 1,$ etc. to 40. At 41 it fails.[75]

***The reactionary Irish idealist George Berkeley, after a spell in North America in the slave period, ended up as the Bishop of Cloyne. He is now remembered as the author of the ultra-idealist philosophy of 'Solipsism' (from the Latin 'Solus ipse' – 'I alone'). He also ventured into mathematics. In the *Analyst* he took issue with the 'infidel' mathematicians on the concept of infinitesimals, which he described derisively as 'the ghosts of departed quantities'. This provoked Colin McLaurin, who had originally intended to keep silent, to publish his *Treatise on Fluxions* (1742). While Berkeley remains an odd spot in the history of philosophy, McLaurin's name and work have an honoured place in mathematics.[76]

as a machine. La Mettrie took the idea ,to its logical conclusion in his anonymous *Man Machine*.[79]

In the forties of the 19th Century, the 'reductionists' of the Helmholtz school* were determined to establish that the physiology of organisms is, ultimately, the action of physical and chemical forces. They were opposed by the 'vitalists' of the Liebig school who maintained that the life-sciences required an extra, 'vital', force.

The synthesis of urea, an 'organic' substance from inorganic matter by Wohler in 1828 should have settled the question, but the controversy continued to rage through the 19th Century and we find that as late as 1861 the great Mendeleyev had to enter the lists on the side of the 'reductionists'.[80]

In organic nature, Engels wrote: '. . . the laws of mechanics are, indeed also valid, but are pushed into the background by other, higher laws. . .'[81] 'Physiology is, of course, the physics and especially the chemistry of the living body, but with that it ceases to be specially chemistry: on the one hand its domain becomes restricted, but, on the other hand, inside this domain it becomes raised to a higher power.'[82]

In recent years the bio-chemist Joseph Needham concluded after experimental study that organic nature follows not physico-chemical laws but 'congruent laws on a higher plane.'[84]

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Hegel was emphatic: 'If the truth be abstract, it must be untrue. Philosophy is what is most antagonistic to abstraction, it leads back to the concrete.'[85]

Marx and Engels never tired of repeating, after Hegel, that the truth is concrete.

In the *Communist Manifesto* they criticised bourgeois theorists: 'The selfish misconception that induces you to transform into eternal laws of nature and of reason, the social forms springing from your present mode of production and forms of property – historical relations that arise and disappear in the progress of production – this misconception you share with every ruling class that has preceded you.'[86]

* The others were Carl Ludwig, Emil Dubois Reymond and Ernst Brucke. It is of interest that among Brucke's pupils was Sigmund Freud.[83]

As a Russian reviewer* of *Capital* correctly pointed out: 'In his (Marx's) opinion every historical period has laws peculiar to itself. . . As soon as life has gone through a given period of development and is passing over from one given stage to another, it begins also to be controlled by other laws . . .'[87]

When Mikhailovsky described Marx's historical materialism as 'a supra-historical principle', Marx protested: '. . . he is honouring me and shaming me too much . . .' and declared that there were no historico-philosophical 'master-keys'.[88]

Marx also denied that there was an abstract law of population: '. . . every stage of development has its own law of population . . . historically valid within its limits alone . . . '[89]

When attempts were made to explain human history as a continuation of the Darwinian 'struggle for existence' in animal evolution, Engels objected: 'The most that the animal can achieve is to *collect*; man *produces*, he prepares the means of life in the widest sense of the words, which, without him, nature would never have produced. This makes impossible the immediate transference of the laws of life in animal societies to human ones.'[90]

In 1865, Engels pointed out: 'To us, so-called 'economic laws' are not eternal laws of nature, but historical laws which arise and disappear . . .'[91]

In *Anti-Duhring* he wrote: 'Political economy cannot be the same for all countries and for all historical epochs . . . Political economy is . . . essentially a historical science. It deals with material which is historical, that is, continually changing . . . '[92]

Trotsky observed: 'It was not Marx's aim to discover the 'eternal laws' of economy. He denied the existence of such laws. The history of the development of human society is the history of the succession of various systems of economy, each operating in accordance with its own laws.'[93]

To illustrate that each law has only a limited range of validity, Plekhanov gave a graphic example: consider a man eating bread. The laws that work on the bread once it is in the stomach are the laws of digestion; but the laws that determined why the man eats bread and not cake, are the laws of economics.[94]

Dialectics rejects all concepts of eternal and abstract truth. Lenin repeated after Hegel and Marx: 'The fundamental thesis of

* I.I. Kaufmann in the Petersburg European Messenger, May 1872.

dialectics is: there is no such thing as abstract truth, truth is always concrete.'[95]

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Before we pass on, let us make brief mention of a profound idea Niels Bohr put forward in 1922 as his 'Correspondence Principle'. He pointed out that the 'new' laws of physics should carry the 'classical' laws on the face of them: the equations of relativity should reduce to classical form if the velocity of the body is very small compared to the velocity of light; quantum laws likewise should become classical if Planck's constant *h* is set to zero.*

In the words of Einstein and Infeld: 'The new theory shows the merits as well as the limitations of the old theory and allows us to regain our concepts from a higher level . . . '[96]

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A similar train of thought is to be found in one of Marx's unfinished drafts of 1857-8: 'The anatomy of man is a key to the anatomy of the ape. On the other hand, rudiments of more advanced forms in the lower species of animals can only be understood when the more advanced forms are already known. Bourgeois economy thus provides a key to the economy of antiquity.'[97]

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* For simple illustrations: the equations of solid coordinate geometry in x, y and z, reduce to the equations of plane coordinate geometry when z is set to zero; the wave theory of light approximates to geometrical optics when the wave-length tends to zero; again, the laws of statics may be considered to be a special case of the laws of dynamics. See Bohr's contribution in *Einstein, Philosopher Scientist*, Tudor N.Y. 1949; L. de Broglie *The Revolution in Physics*, Routledge 1954, Chap. VII; also *Philosophical Problems of Elementary Particle Physics* Moscow 1968, especially p. 411 et seq.

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Chapter Six

The Unity of Opposites

Metaphysical thinking divides phenomena into immutable opposites: good and bad, love and hate, life and death, truth and error, and so on.

Dialectics, on the other hand, recognizes not merely the co-existence, but the unity of opposites, their inter-penetration, inter-action, their transformation, one into the other.

Marx, referring to Hegel, wrote: 'A most profound yet fantastic speculator on the principles which govern the movements of humanity was wont to extol as one of the ruling secrets of nature what he called the law of contact of extremes. The timely proverb that 'extremes meet' was, in his view, a grand and potent truth in every sphere of life; an axiom with which the philosopher could as little dispense as the astronomer with the laws of Kepler or the great discovery of Newton.'[1]

Engels noted: 'The dialectics that has found its way into popular consciousness is expressed in the old saying that extremes meet.'[2]

'Good' and 'Bad'

Daily experience teaches us that a person can be 'good' at one time, 'bad' at another. No one can really be classified as permanently good or permanently bad, or placed in any other fixed category.

The French poet Baudelaire observed: 'In every man there are two simultaneous aspirants — one for God and one for Satan.'[3]

Leo Tolstoy expressed this fact very forcefully:

> 'One of the most widespread superstitions is that every man has some distinguishing quality: one is kind, another cruel, a third wise or stupid, or energetic, or apathetic. Men are not really like that. We may say of a man that he is more often kind than cruel, more often wise than stupid, more often energetic than apathetic, or the reverse; but it would not be true to say of one man that he is kind and wise, of another that he is bad and stupid. And yet we always classify mankind in this way. And this is false. Men are like rivers: the water is the same in one and all: but every river is narrower, more rapid there, here slower, there broader, now clear, now dull, now cold, now warm. It is the same with men. Every man bears in himself germs of every human quality; but sometimes one quality manifests itself, sometimes another, and the man often *becomes unlike himself*, while still remaining the same man.'[4] (Our italics.)

Love and Hate

In the field of human psychology, love and hate are not merely opposite, but co-existent and inter-penetrating emotions.

The Ancients were aware of this. Empedocles of Acragas, Sicily, in the 5th Century B.C. taught that 'Love and Hate move the world.'*[5]

Literary genius realized this fact intuitively.

Shakespeare in his Sonnet (CXXIX) sang:

'Past Reason hunted, and no sooner had,
'Past Reason hated.'

He made Juliet confess: 'My only love sprung from my only hate!'[6]

Leo Tolstoy made a deep psychological observation: 'A period of love, a period of hate; a weak period of love, a brief period of hate; an intense period of love, a prolonged period of hate. We did not then realize that this love and hate were different aspects of one and the same animal feeling.'[7]

The inter-play of opposite emotions dominates the craggy literary monuments left to us by Fyodor Dostoevsky, himself described by a biographer as 'a man of fire and ice'.[3]

* By which he probably also meant Attraction-Repulsion, Condensation-Rarefaction. Here, as always, we must be cautious of reading into the words of the ancients meanings that they probably never intended.

In her touching memoirs, Marx's daughter Eleanor, said her father 'could hate so fiercely only because he could love so profoundly.'[8]

Much of the work of D.H. Lawrence contains this love-hate theme. In his *Sons and Lovers* (1913) we find: 'Something in him hated her again for submitting him to this torture of nearness. And he loved her. . .'[9] In his *Rainbow* (1929) he speaks of 'a heart hard with tenderness'[10], and again: 'So it went on continually, the recurrence of love and conflict between them. One day it seemed as if everything was shattered, all life spoiled, ruined, desolated and laid waste. The next day it was all marvellous again, just marvellous. One day she thought she would go mad from his very presence, the sound of his drinking was detestable to her. The next day she loved and rejoiced in the way he crossed the floor, he was sun, moon and stars in one. . .'[11]

Sigmund Freud, in 1882, long before his scientific study of the Psyche, observed in a letter to his fiancee: 'Only in logic are contradictions unable to co-exist; in feelings they quite happily continue alongside each other.'[12]

The term 'ambivalence' which was coined by Eugen Bleuler to describe the phenomenon was immediately adopted by Freud.[13]

In his Clark University Lectures (1909), he noted that 'instincts occur in pairs of opposites. . .'[14]

In 1937, he wrote: 'The circumstances that many instincts are manifested almost from the first in pairs of opposites (is) a very remarkable phenomenon – and one strange to the lay public – which is termed the ambivalence of feeling – Psychoanalysis adds that the conflicting feelings not infrequently have the same person for their object . . .'[15]

In his last, unfinished work, *An Outline of Psychoanalysis* (1938), Freud, acknowledging the philosophical intuition of Empedocles, wrote: 'This interaction of the two basic instincts with and against each other gives rise to the whole variegation of the phenomena of life. The analogy of our two basic instincts extends from the region of animate things to the pair of opposing forces – attraction and repulsion – which rule the inorganic world.'[16]

These were not incidental observations, but statements of one of

the basic principles of psychoanalysis.* Freud has been accused of 'obstinate dualism', and of 'a very characteristic kind of dialectical thinking that tends to base theories on the interaction of two opposite powers', of having: a difficulty in contemplating any topic unless he could divide it into two opposites. . .'[17]

Pleasure and Pain

The intimate connection between pleasure and pain was long recognized by the ancients.** While this is not quite our subject, let us listen for a while, to what some poets and writers had to say.

In Shakespeare's *Romeo and Juliet* (II, iii), Juliet exclaims: '. . . parting is such sweet sorrow. . .' In *As You Like It* we hear of 'the food of sweet and bitter fancy. . .' (VI, iii); in *The Comedy of Errors* of 'pleasing punishment . . . (I, i); and in *Antony and Cleopatra*: 'The stroke of death is as a lover's pinch, which hurts and is desired.' (V, ii).

From John Seldon (1584-1654) we hear: 'Pleasure is nothing else but the intermission of pain.' From John Dryden (1631-1700): 'Sweet is pleasure after pain. . .' And from William Congreve (1670-1729): 'I love to give pain. . .'

Heinrich Heine sang of 'Ravishing torture and blissful pain/ terror and ecstasy!' In Heine's poetry, as also in his life, love and pain are equivalent.

Guy de Maupassant, in his *Olive Orchard*, wrote of 'the perverse charm of a smile, hateful but caressing.'

Pleasure in inflicting pain ('Sadism') and pleasure in suffering it ('Masochism') are two complementary manifestations, difficult to distinguish or separate.***

Havelock Ellis, in his exploration of this 'most difficult (and) most fundamental' problem, quotes the physiologist Burdach, who

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* See inter alia: *Three Contributions to the Theory of Sex*, Modern Library, 1938, p. 598 et seq.; *Totem and Taboo*, Chapter II; *The Ego and the Id*, Hogarth, p. 59; *Beyond the Pleasure Principle*, Hogarth, p. 68. Also *Primer of Psychonalaysis*, Calvin S. S. Hall, Mentor, 1954, p. 91. et seq.

* *Havelock Ellis, Studies in the Psychology of Sex, Part II, Section2, summarizes the literature up to 1903.

***The terms 'Sadism' after the Marquis de Sade (1740-1814), the French writer, and 'Masochism', after Leopold Sacher Masoch (1836-1895) the Austrian novelist were coined c. 1882 by Prof. R. von Kraft-Ebing (1840-1902) of Vienna. (His pioneer work was *The Psychopathia Sexualis*, 1886.)

recognized that: 'It is precisely the alliance of pleasure and pain which constitutes the voluptuous sensation.'[18] He also notes that the 'biological conditions of courtship impose an aggressive as well as a submissive role to the male. . .' He concludes that between 'Sadism' and 'Masochism', 'there is no real line of demarcation . . . They cannot, therefore, be regarded, as opposite manifestations.'[20]

Later writers have referred to these phenomena by the compound term 'Sado-Masochism'.

Sigmund Freud noted: 'It has also been claimed that every pain contains in itself the possibility of a pleasurable sensation. . .'[21], and that 'Sadism' and 'Masochism' are 'the most important representatives' of the 'pairs of opposite instincts. . .'[22]

In his *Beyond the Pleasure Principle* (1920) Freud gave the study of these phenomena a new dimension, a depth lacking in the earlier literature. Here, he speaks of the 'Pleasure-Pain Principle'. It is worthwhile, in this connection, to recall Havelock Ellis' assessment: 'everything Freud has touched – that indeed is always a mark of genius – takes on a new significance and becomes of importance . . .'[23]

Life and Death

Man has long recognized, intuitively, that life and death are not distinct, but inter-connected phenomena. In many mythologies the gods are not only 'Creators', but also 'Destroyers'.

It is now common scientific knowledge that the process of life – 'metabolism' – consists of the process of growth, 'anabolism', and the process of decay, 'katabolism'. Under normal conditions, in youth, 'the forces of growth' have the better of 'the forces of death'. In adulthood, the forces equalize, living tissues replace the dead, while all perceptible growth ceases. As old age sets in, 'the forces of death' begin to predominate and finally the organism ceases to live. In Claude Bernard's apt definition: 'Life is the ensemble of functions that resist death.'[24]

Life and death are inter-related phenomena, the result of forces in constant conflict.

While it was Hegel who drew attention to the philosophical importance of this fact, his contemporary Goethe set it in poetry:

'Birth and the Grave,
An enternal sea. . .'[25]

Engels pointed out that: 'Life is also a contradiction which is present in things and processes themselves, and which constantly asserts and solves itself; and as soon as the contradiction ceases, life, too, comes to an end . . .'[26]

Concisely, 'Living means dying.'[27]

Quite early in his work, in 1910, Freud discovered the motivations of suicide – 'self-capital-punishment': the unconscious forces of self-destruction become stronger, for a moment, than those of self-preservation.[28] However, it is a flash-point, if unsuccessful, that may never be repeated in a life-time.*

In later years, in working out a theory of instincts, he proposed the concept of a 'death instinct' as opposed to a life instinct. 'Eros' he claimed was always opposed by 'Thanatos'.**

Hegel's Formulation

In his *Logic* Hegel stressed the unity of opposites:

'Positive and negative are supposed to express an absolute difference. The two, however, are at bottom the same; the name of either might be transformed to the other. Thus, for example, debts and assets are not two particular, self-subsisting species of property. What is negative to the debtor is positive to the creditor. A way to the East is also a way to the West. Positive and negative are therefore intrinsically conditioned by one another, and exist only in relation to each other. The north pole of a magnet cannot be without the south pole and vice versa. If we cut a magnet in two, we have not a north pole in one piece and a south pole in the other. Similarly, in electricity, the positive and negative are not two diverse and independent fluids. In opposition the difference is not confronted by *any* other, but by *its* other . . .'[30]

Let us add to Hegel's series of examples, Newton's exact formulation of the unity of opposites for mechanical forces – the well-known 'Third Law of Motion': 'To every action there is always opposed an equal and opposite reaction.' (*Principia*, 1686).

This fundamental law was already implicit in Archimedes' Law

* Jurists know this fact intuitively. The punishment for attempted suicide is a 'binding over' for good behaviour.

** See, inter alia, *Beyond the Pleasure Principle*, p. 68 et seq. and *Outline of Psychoanalysis*, p. 6 et seq. Havelock Ellis observed that 'detumescence' is almost death, and quoted the ancient saying: 'Omne animal est post coitum triste.' *In Sons and Lovers*, D.H. Lawrence has an interesting line: 'Why did the thought of death, the after-life, seem so sweet and consoling?'[29]

of Floatation, historically one of the first laws of physics, (announced along with the Laws of the Lever): The weight of a body floating in a fluid is offset by the upthrust of the weight of the fluid displaced.'

*

The idea can be traced back to the 6th Century B.C.

Anaximander, the second Western philosopher, (after Thales, the first) was the first to conceive of *abstract* 'oppositions' – wet-dry, hot-cold – balancing each other.[31]

In the next century, Heraclitus announced his 'Doctrine of Opposite Tensions.'

Opposites Inter-act

The co-existence of opposites is not a static state; opposites interact, there is attraction *and* repulsion.

To quote Sir Isaac Newton: 'I am inclined by many reasons to suspect that they (the phenomena of Nature) may all depend upon certain forces by which the particles of bodies, by some causes hitherto unknown, are either mutually impelled towards each other, and cohere in regular figures, or are repelled and recede from each other.'[32]

The attraction and repulsion of magnetic poles was known from ancient times; so was electrostatic attraction. Electrostatic repulsion was first observed by Otto von Guericke.

Engels observed: 'Where there is attraction, it must be complemented by repulsion. Hence Hegel was right in saying that the essence of matter is attraction *and* repulsion.'[33]

Newton gave us his 'universal' law of gravitation – an attractive force between all material bodies. If this were the only force, the universe would have packed up long ago. To explain the 'expanding universe', Einstein for a time, 1917-1931, used the postulate of the 'cosmological constant' which was counter-posed as a universal repulsive force.[34]

Physicists tell us that within the molecule there are attractive as well as repulsive forces, which, between them, assure molecular stability.

Numbers* – Rational and Irrational

Perhaps the first 'intellectual crisis' in the history of man was that of the Pythagoreans in the 5th Century B.C.

In using counting numbers for the purpose of measurement they came across some numbers like the square root of 2, which, while representing a definite measurement, (the length of the hypoteneuse of a right-angled triangle with unit arms), could not be expressed as a ratio of two integers.

They probably did not want to divulge their problem, and such numbers they called 'alogon' (unspeakable). We name them 'irrational', non-ratio, as opposed to 'rational' numbers.

The 'crisis' was solved geometrically by Eudoxus in Greek times, and analytically only in the 19th Century (Cantor, Dedekind), when irrationals found their place along with the rationals on Euler's 'real number line'.**

Numbers – Positive and Negative

Diophantus of Theon (later of Alexandria), the last great algebraist*** of antiquity, was able to recognize negative numbers****, but rejected them as absurd and impossible, and for a thousand years European mathematicians failed to explore the interesting — and vital – world of the negative.

The Chinese were probably the first to use negative numbers, and we know that in 7th Century India, Brahmagupta used negatives in his calculations.

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* Engels discusses mathematical topics in his *Dialectics of Nature*, (Moscow Edition, 1964, p. 261 et seq.) Marx's mathematical manuscripts are, at the time of writing, not available in English translation. [Published by New Park Publications in 1983.]

** Lancelot Hogben aptly describes counting numbers as 'flock numbers' and measuring numbers as 'field numbers', thus, not only drawing the important distinction between the two, but also indicating their origin in practical activity.[35] The ubiquitous number 'pye', the ratio of the circumference of a circle to its diameter, is not a counting number. For a discussion of the 'crisis' see, inter alia: B. Farrington: *Greek Science*, Pelican, 1949, pp. 48-49. T. Dantzig: *Number, the Language of Science*, A. & U., London, 1930. M. Kline: *Mathematics in Western Culture*, OUP, 1953, pp. 35-38.

***Diophantus (c. 275 B.C.) wrote the earliest known treatise on algebra which he entitled 'Arithmetica'. It was unsurpassed for a millenium. He noted that, in transposition, the addend in an algebraic equation becomes a subtrahend and vice versa. So also did the 9th century Arabic scholar Mohamed ibn Musa al-Khowarizimi, in his work *Aljebr w'almuquabala*, ('restoration and reduction'), from which we derive our word 'algebra'.[38]

****For an interesting fictionalized account of the discovery of negative numbers in China, see A.H. Read: *A Signpost to Mathematics* Thrift Books, Watts, 1951, p. 84 et seq.)

In the 13th Century, Fibonacci (Leonardo of Pisa) conceded (c. 1202 A.D.) that negative numbers could express debts. By the end of the 16th Century, negative numbers became respectable. In 1629, the Frenchman Girard showed how to depict them geometrically.[36] However, even Descartes called them 'false numbers'.[37] It was only in 1659 that Hudde used variables which could be negative as well as positive and thus opened up the negative domain to mathematical investigation.

Numbers — 'Real' and 'Imaginary'

Diophantus also gave us the 'rule of signs'* according to which no signed number multiplied by itself could be negative.

The concept of the square root of a negative number, first used by Cardanol in 1545, was described by Napier as a 'ghost number'[39], and as late as 1702 by Leibnitz as 'a fine and wonderful invention of a marvellous mind, almost an amphibian between things that are and things that are not,'[40]

Descartes (1637) called them 'imaginaries', a name that is still used. Euler (1748) symbolized the 'impossible' square root of minus one (- 1) by the letter *i*.[41] However, he too, maintained that such numbers were 'necessarily . . . imaginary or impossible. . .' (*Algebra*, 1770).[42]

Wessel of Norway (1797) and Argand of Switzerland (1806) showed that 'complex numbers' (combinations of 'real' and 'imaginary' numbers, so named by Gauss in 1831) could be 'photographed', that is, represented graphically.

Gauss was convinced that 'just as objective an existence can be assigned to imaginary as to negative quantities.'[43] By the early 19th century complex numbers had found their useful and important function in mathematics, physics and engineering and when we advance a little in mathematics, we will be compelled to agree with J. Hadamard's interesting observation that 'the shortest path between two truths in the real domain passes through the complex domain.'[44]

In 1821 Cauchy pointed out that the complex roots of an equation occur in opposite ('conjugate') pairs, i.e., if $(x + iy)$ is a

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* In modern symbolism: + × + = +; + × - = -; - × + = -; and - × - = +. This applies also in reverse: + = + × +, or - × -. So it appeared for a long time that while positive numbers could have squares (or an even number of roots), negative numbers could not.

root, so also is $(x - iy)$; and that in calculations $-i$ is equivalent to $+i$, though, being reciprocals, they are not identical.

Before passing on, let us consider the following simple-looking equations: (1) $x - 1 = 0$; (2) $2x - 1 = 0$; (3) $x + 1 = 0$; $x^2 - 2 = 0$; (5) $x^2 + 1 = 0$.

The solution of the first is $x = 1$, a whole number; of the second is $x = ½$, a fraction; of the third is $x = -1$, a negative number; of the fourth is the square root of 2, an irrational number; and of the fifth is $x = i$, an imaginary number.*

Between the successful solutions of the first and fifth equations lies a period of about two thousand years!

The Operations of Mathematics

Let us note with the ancients[45] that the six operations of arithmetic are extensions of the fundamental: involution (raising to powers) is extended multiplication, as multiplication is an extension of addition; so also, evolution (extracting roots) is extended division and division is an extension of subtraction.

These operations can be grouped in three pairs of opposite processes: addition and its inverse subtraction; multiplication and its inverse division; involution and its inverse evolution.

Once the concept of negative is introduced, subtraction becomes identical with addition – change the sign and add; introduce the concept of reciprocals (Mahavira of India, c. 850 A.D.), and division is multiplication by the reciprocal of the divisor; introduce fractional exponents (Oresme, c. 1380) and evolution is the same as involution.

The work of Napier (1614) and others not only gave us compact computational methods – the familiar operations of finding logarithms and anti-logarithms – but also made the unity of arithmetical operations obvious: multiplication is performed by the addition of logarithms, division by subtraction, etc.

In the calculus of Newton and Leibnitz we have another pair of opposite operations: differentiation and integration, in the more expressive and appropriate terminology of recent text-books, finding the 'derivative; and the 'anti-derivative' of functions.

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* After A.G. Kurosh: *Algebraic Equations*, Mir, Moscow, 1977.

Infinite Proceses and Finite Results

There is a 'paradox', the Greek 'dichotomy' – halving – which was known at least as far back as Euclid's time.[46] Take a line segment and bisect it; then bisect the remaining half, then the remaining quarter, and so on. This is a process that can be carried on indefinitely, for the line segment itself will never be exhausted.

Translated into arithmetic and modern notation, we have the infinite series: $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \ldots$ the sum of which approaches but cannot exceed or even equal unity. In the language of Newton and Leibnitz, unity is the 'limit' of this infinite series.

The concept of 'limits' was investigated in the 18th and 19th centuries and is now fundamental in mathematics.*

Not only do some infinite series have finite sums, some 'finite' quantities can be expanded and represented by an infinite series.[47]

Engels noted: 'To common sense it appears an absurdity to resolve a definite magnitude, e.g., a binomial expression, into an infinite series, that is, into something indefinite. . .'[48]

Erwin Schrodinger has pointed out that '. . . in the case of Greek Science the idea of the infinite is scarcely understood. The concept of the limitless process frightened the Greeks as is evidenced in the well-known paradox of Achilles and the tortoise . . .'[49]***

It is no wonder that it took over two thousand years – from Euclid through Newton to Abel – for the binomial theorem to be fully worked out.[50]

As a special case of the binomial theorem we have the expansion of $(1 + \frac{1}{n})^n$ which as an infinite series has a finite sum (limit), which Euler baptized (c. 1727) with the symbol *e*. Many mathematical roads are mapped out by *e*, it is ubiquitous and enters into the analysis of a whole range of phenomena, from organic growth to radio-active decay.***

* For a literary description of this concept, readers are referred to 'The Mouse's Tale' in Chapter III of *Alice in Wonderland*. Lewis Carroll, as we have seen, was, among other things, a mathematician.

** This 'paradox' is discussed shortly.

***See D'Arcy W. Thompson *On Growth and Form*, p. 139 et seq. for a series of examples and a discussion.

Existence and Non-Existence

Can 'non-existence' exist? To the question posed in this paradoxical form, Parmenides of Elea (6th Century B.C.) gave the ready answer: 'No!' This was for those times, and also for ours, not a mere play on words. It was a philosophical question, and we may also suspect, a political question. Parmenides denied that change takes place and repudiated the method of observations. In doing so he was rejecting the teachings of the Pythagorean school. [51]

The correct and profound answer came from Parmenides' contemporary, Heraclitus of Ephesus, with whom, according to Hegel, dialectics began.[52] Heraclitus taught that 'all things flow'[53]; 'everything is becoming'[54]; 'Existence and non-existence are meaningless in a changing world, everything is becoming. . .'[55]

Hegel readily adopted this view: 'Existence is in part mere appearance, and only in part reality.'[56] '*Neither in heaven nor on earth is there anything not containing both Being and Nothing.*'.[57] (Hegel's italics).

'Pure Being and pure Nothing are. . . the same. . .' 'Their union is Becoming. . .'[58] 'Beginning contains both *Nichts* (nothing) and *Sein* (being) – it is their unity. . .' and again, 'that which is beginning, as yet is *not*; it is merely advancing towards being. . .'[59]

On the ancient philosopher's intuition, Hegel commented: 'The recognition of this fact that being and not-Being are only abstractions devoid of truth, that the first is to be found only in Becoming, forms a great advance. . .'[60]

Engels wrote: '. . . nature does not just *exist*, but *comes into* being and passes away. . .'[61] and paid tribute to Heraclitus: 'This primitive, naive, yet intrinsically correct conception of the world was that of ancient Greek philosophy, and was first clearly formulated by Heraclitus: everything is and also is not, for everything is in flux, is constantly changing, constantly coming into being and passing away.'[62]

Continuity and Discontinuity – Space and Time

Zeno of Elea, a follower of Parmenides, in the 5th century B.C. posed four paradoxes,[63] the most famous of which is that of the race between Achilles and the tortoise.

Achilles, who, let us say, was able to run ten times as fast as the

tortoise, had a hundred yard handicap. When Achilles covered the hundred yards, the tortoise was ten yards ahead; Achilles then covered the ten yards and the tortoise was one yard ahead; when the yard was covered, the tortoise was one-tenth of a yard ahead . . . Achilles could never overtake the tortoise.

Achilles pleaded, 'Let me overstep the limits',[64] but then the Greeks, save for Archimedes, had no inkling of the concept of limits, and Achilles was left kicking his heels for two millenia, until the Renaissance and the work of Rene Descartes and the introduction of time into geometry.[65]

In his time, Aristotle pointed out that space and time were infinitely divisible but not infinitely divided[66]; time cannot be divided into a series of 'individual "Nows" '[67]; motion is *not* a sum of states of rest, rather is rest a special case of motion.[68]

Centuries later, James Clerk Maxwell commented: '. . . up to Zeno's time, time was regarded as made up of a finite number of moments while space was confessed to be divisible without limit.'[69]*

Another of Zeno's paradoxes is said to have been posed at an archery contest. Indicating an arrow in flight he had said: Either the arrow is there, or, it is not there. It cannot be not there. Therefore, it is there, and does not move.

Motion was, thus, logically 'refuted'.**

Actually, Zeno only demonstrated the inadequacy of the formal logic of the period.

Heraclitus, as we have seen, gave us the solution. There is no existence or non-existence; there is only becoming. Zeno's arrow has not only the capacity of being there, but also the ability of being not-there, that is, of moving.

In explanation of the paradox, Hegel wrote: 'If we speak of motion in general, we say that the body is in one place and then it goes to another; because it moves it is no longer in the first, but not yet in the second; were it in either it would be at rest. If we say that it is between both, that is to say nothing at all, for were it between

* Today every school-child is taught that velocity (or speed) is a time average, not a distance average, and Zeno's paradox is no longer a paradox. However, let us remember that it took mankind about two thousand years to solve the problem.

**Diogenes 'refuted' Zeno and 'proved' motion by walking up and down. 'A vulgar refutation', commented Hegel and added: 'When a pupil was satisfied with this refutation, Diogenes beat him, on the grounds that since the teacher had disputed with reasons, the only valid refutation is one derived from reasons. Men have not merely to satisfy themselves by sensuous certainty but also to understand.'[72]

both, it would be in a place, and this would present the same difficulty. But movement means to be in this place and not to be in it; this is the continuity of space and time – and it is this which first makes motion possible.'[70]

He added: 'What makes the difficulty is always thought alone, since it keeps apart the moments of an object which in their separation are really united.'[71]

On this question Engels wrote: 'So long as we consider things as static and lifeless, each one by itself, alongside of and after each other, it is true that we do not run up against any contradiction in them. We find certain qualities which are partly common to, partly diverse from, and even contradictory to each other, but which in this case are distributed among different objects and therefore contain no contradiction. Within the limits of this sphere of thought we can get along on the basis of the usual metaphysical mode of thought. But the position is quite different as soon as we consider things in their motion, change, their life, their reciprocal influence on one another. Then we immediately became involved in contradictions. Motion itself is a contradiction: even simple mechanical change of place can only come about through a body at one and the same moment of time being both in one place and in another place, being in one and the same place and also not in it. And the continuous assertion and the simultaneous solution of this contradiction is precisely what motion is.'[73]

Plekhanov commented: 'The movement of matter underlies all the phenomena of nature. But what is movement? It is an obvious contradiction. Should anyone ask you whether a body in motion is at a particular spot at a particular time, you will be unable, with the best will in the world, to answer in accordance with. . . the formula, 'Yes is yes, and no is no.' A body in motion is at a given point, and at the same time it is not there. We can only consider it in accordance with the formula, 'yes is no, and no is yes.' This moving body thus presents itself as an irrefutable argument in favour of the 'logic of contradiction'; and one who is unwilling to accept this logic will be forced to proclaim with Zeno, that motion is merely an illusion of the senses.'[74]

The problem of the logical representation of motion is not a mere play on words. It is the central question of dialectics and has been with us since Zeno.

Modern theoretical physics was compelled, not accidentally, to explore the problem again, and in 1927, Werner Heisenberg gave us his celebrated 'Uncertainty Principle', which we mention without discussion.

Louis de Broglie summed up the problem from the physicists' point of view: 'Exact localization in time and space is a sort of idealization which excluded all evolution and all dynamism; the idea of a state of motion taken in all its purity is on the contrary a dynamic idealization contradictory in principle with the concepts of position and instant.'[75]

Motion presents the basic example of the unit of opposites. As Lenin noted in 1915:

> 'We cannot imagine, express, measure, depict movement, without interrupting continuity, without simplifying, coarsening, dismembering, strangling that which is living. The representation of movement by means of thought always makes coarse, kills – and not only by means of thought, but also by sense-perception, and not only of movement, but *every concept.*
>
> And in this lies the essence of dialectics.
>
> And precisely *this essence* is expressed by the formula: the unity, identity of opposites.'[76]

Continuity and Discontinuity – Matter

One of the major questions of classical Greek philosophy was: Is matter infinitely divisible?

Leucippus (6th Century B.C.) and Democritus (460 - 357 B.C.) both of Abdera, and Epicurus (341 - 270 B.C.) of Athens maintained that matter was composed of ultimately indivisible particles – atoms.

Schrodinger states that: 'They invented the first discontinuity.'[77]

Democritus went further and declared, boldly, that the world is composed of atoms and void and all else is pure imagination.*

Democritus is also credited with being the first to say that the Milky Way is composed of a myriad of distant stars.** The great atomist would not grant continuity even to the mists of the heavens.

* In the modern version of Oliver Heaviside: 'There are only two things in the world: matter and energy: everything else is moonshine.'[78]

** Confirmation came in 1609 when Galileo turned his telescope to the skies.

Plato and Aristotle, to mention only the most famous, opposed the atomist view and maintained that matter was continuous and infinitely divisible.

The question of the atomicity of matter was, for those times, a philosophical problem, and apart from being celebrated in Latin verse by Lucretius (98 - 55 B.C.) in his *The Nature of Things*, the idea lay dormant for one thousand seven hundred years.

*

Interest was revived in Europe by the publication of a commentary on Epicurus by Gassendi (1649), and, before long, Boyle, Descartes and Newton were convinced that an atomic theory of matter was necesary to explain the observations of physics.

It was left to the chemists, however, to give the idea new life at the beginning of the 19th century.

John Dalton revived the theory in 1803 to explain the laws of chemical combination.

Armedeo Avogadro, in 1811, in interpreting the laws of chemical combination of gases (Gay-Lussac, 1809), drew a distinction between atoms and molecules, and the discreteness of matter had to be an accepted scientific fact. But Avogadro's ideas passed unnoticed for half a century until Cannizaro popularized them in 1858.

Laplace, c. 1806, used the idea to explain the phenomena of surface tension.

In the 19th Century, Clausius, Maxwell (1859) and Boltzmann based their kinetic theory on the molecular theory of matter, and were able to derive, theoretically, well known experimental laws of macroscopic behaviour.

The discreteness of electricity was implicit in Faraday's laws of electrolysis (1834), though Faraday himself, who introduced the word 'ion', used it as a collective concept.

In 1881, Helmholtz, in his 'Faraday Lecture', indicated the atomicity of electricity. In 1887 Arhennius gave us a consistent theory of the corpuscular 'ion'.

In 1891, George Johnson Stoney in anticipation, gave the name 'electron' to the fundamental particle of electricity. In May 1897, J.J. Thompson succeeded not only in proving its existence but also measuring its properties. The electron was found to be a 'negatively' charged particle.

The atom being electrically neutral, a positively charged particle had to exist.

With the discovery of radio-activity by Henri Bequerel (1896), its further study by Pierre and Marie Curie, and the work of Rutherford, a positively charged particle was discovered, and, in 1920, named the 'proton'.

In 1919, Rutherford successfully 'smashed' the atom and also transmitted it, and the atom was thereafter indivisible, as de Broglie has aptly commented, 'only etymologically'.

*

In a curious passage in *Materialism and Empirio-Criticism*, we find: '. . . It has become possible to reduce matter to electricity; the atom can be explained as resembling an infinitely small system, within which negative electrons move around a positive electron . . .'[80]

Lenin wrote these lines in *1908*. We do not know the source of Lenin's scientific information, as the bibliography mentions only the work of J.J. Thomson, *The Corpuscular Theory of Matter*, 1907. J.J. Thomson's model of the atom (1904), while being a unity of oppositely charged particles, was certainly not an orbital one.

The nuclear atom was conceived by Rutherford at Manchester only in February 1911 and his results published in the *Philosophical Magazine* of June of that year.*

It is thus significant that Lenin, in anticipation, accepted the orbital model as the correct one for the given historical period and hailed it as 'another corroboration of dialectical materialism.'[81]

Continuity and Discontinuity – Energy**

In 1704, Sir Isaac Newton posed the problem: 'Are rays of light not very small corpuscles emitted by luminescent bodies?'[82] To the end of his days he refused to give a definite answer to the question.

* The Rutherford atomic model was theoretically unstable, and was soon replaced, in 1913, by the quantized Rutherford-Bohr model which fitted experimental facts.

** Without going into 19th Century controversies of the subject which cloud two whole chapters of Engels' *Dialectics of Nature (Basic Forms of Motion*, and the Measure of Motion, 1880-1), we give the presently accepted definitions: Energy (the English word was coined by Thomas Young in 1807) is now defined as 'the capacity of doing work' (James Thomson c. 1852). From Newton's time two types were distinguished: energy by virtue of motion, kinetic energy (Thomson and Tait 1867) which was first correctly defined by G.G. Coriolis (1826) as half mass times the square of the velocity, and potential energy (Rankine, 1853) by virtue of position or configuration. Hertz showed their equivalence.

The experimental evidence accumulated in the 18th and 19th centuries led to the adoption of the wave theory of light (Huyghens 1690, Young 1812, Fresnel 1816). According to this view, light consists of waves which are continuous and undulatory.

The wave theory achieved spectacular success with Maxwell's prediction (1862) of the existence of 'electro-magnetic waves', and their experimental discovery by Hertz in 1888. They were used in sending 'wireless' signals by A.S. Popov in Russia (7th May 1895) and a little later by G. Marconi in England (4th June 1896).

At the same time, Maxwell, in effect, undermined the wave theory of light by his *theoretical* discovery of the 'pressure' of light (1873). This was experimentally proved by P.N. Lebedev in 1900 (in the case of solids) and in 1907 - 10 (in the case of gases).

The inescapable conclusion, ignored by scientists until Einstein, was that electro-magnetic waves do have momentum – defined as mass times velocity.

*

The 'photo-electric' effect, the emission of electrons by the absorption of light, was discovered by Hertz in 1887 and studied by W. Hallwachs (1888) and explained by Stoletov in the next year.

*

On November 8th, 1895, W.C. Roentgen of the University of Wurzburg, discovered 'X-rays'.

According to G.P. Thomson, this discovery 'forms indeed an epoch, dividing the old physics from the new, the physics of continuity from that of the discontinuous units. . .'[83]

*

On December 14th, 1900, Max Planck, as a result of his studies in the radiation of heat, was compelled to put forward his revolutionary hypothesis that energy is emitted in discrete 'packets', which he called 'quanta'. He introduced a new universal constant h, now known as 'Planck's Constant', which connects two fundamental physical quantities by the simple formula: Energy equals the frequency multiplied by h.

For five years this concept found no other uses.

Then, on September 26th, 1905, Einstein in his analysis of the

phenomena of the absorption of light announced that he was compelled to assume that light was not only discrete in emission but also corpuscular in nature.* Einstein's particles of light were later named 'photons'.

In the same year Einstein made the profound discoveries that all forms of energy possess inertia (or mass), and that *energy and mass are inter-convertible*. He gave us the epoch-making formula connecting energy (E) and mass (m): $E = mc^2$, where c is the velocity of light.**

What, then, is light? Wave or particle?

It is said that W.L. Bragg once made the flippant confession that in keeping with his lecture time-table, on Mondays, Wednesdays and Fridays, light consisted of waves, and that on Tuesdays and Thursdays, of particles.[85] His slightly serious explanation: '. . . a photon consists of a wave in the future and a particle in the past. . .' is imaginative, but takes us no further.[86]

A.H. Compton was much more helpful when he wrote: 'Whenever radiation *does* something, it does it as particles.'[87] (Our italics).

*

In 1905, Henri Poincare in *The Value of Science* announced 'a crisis' in physics, the principles of which were 'in ruins'.[88] Abel Rey, in 1907, declared that 'matter has disappeared'.[89]

*

Lenin devoted considerable attention to 'the crisis', to the extent of travelling from Zurich to London in May 1908, to read the latest literature in the British Museum.***

He devoted a whole Chapter in his *Materialism and Empirio-Criticism* to an analysis of the views of Poincare and Rey.

There, he made the correct diagnosis of 'the crisis': 'Modern physics is in travail; it is giving birth to dialectical materialism.'[90]

*

Within a few years, Planck's constant *h* became ubiquitous in

* In Einstein's analogy, beer is not only sold in pint bottles, it exists in pints.[91]

**Einstein's results were met, with scepticism in some quarters, hostility in others. Even Max Panck felt it necessary, as late as 1912, to apologize for the photon theory.'' Einstein, himself, once wondered whether he was making a fool of himself.[92] He lived to see the 'proof' of his formula with the atom bomb.

***For a Russian exile in the post-1905 period, this must have been a great sacrifice of finances and time.

physics, and was soon enthroned as the 'Queen of the Microcosm.'

In 1913 Sir Ernest Rutherford and Niels Bohr used *h* in their theory of atomic structure in which the energy of electrons in their orbits had discrete values, integral multiples of *h*. Further, orbital electrons could only move in specific orbits, a concept that implied the discreteness of atomic 'space'. (This idea was developed explicitly by Heisenberg in 1930.)

Louis de Broglie*, in 1923, took the concept of 'wave-particle duality' to its logical conclusion by postulating the existence of 'the particle-wave': matter on the atomic scale was both corpuscular (discrete) and undulatory (continuous). Each particle has, associated with it, a wave the frequency of which equals *h* divided by the product of mass and velocity.

Scientists were incredulous until 1927, when Davisson and Germer in the USA and G.P. Thomson in England produced experimental (photographic) evidence of de Broglie's 'matter-waves'.**

With the recent advances in laser technology, the wave concept has come to the fore again.

Niels Bohr pointed out in 1927 that we need 'complementary concepts' to explain the phenomena of light.***

Einstein has written of '. . . two contradictory pictures of reality; separately neither of them fully explains the phenomena of light, but together they do!'[91]

Wolfgang Pauli has observed that, after the work of Einstein, 'it became clear that the existence of the quantum of action implies a radical change in the laws governing microscopic phenomena. In the case of radiation, this change is expressed in the contrast betwen the use of the particle picture and the wave picture for different phenomena.'[92]

* Louis de Broglie must be an excellent stylist in French. (He was elected to the French Academy in 1945). Even in translation his style shows through. In a series of charmingly simple essays (*Matter and Light*, Allen and Unwin, 1939), in which he almost eliminates himself, he gives us a study of the overlapping ranges and the limitations of the two concepts.
It is said that Erwin Schrodinger saw a reference to the de Broglie waves in a foot-note to a paper by Einstein and that this inspired him to develop his 'wave mechanics'. If the story is true, this must be the most important foot-note in the history of science.

**For a first-hand account see G.P. Thomson: *The Inspiration of Science*, OUP, 1961, Ch. IX.
***Convinced of 'complementarity', Bohr, in later life chose for his personal coat of arms, the ancient Chinese symbols Ying and Yang, the two sides of truth.

Matter and 'Anti-Matter'

In 1929, P.A.M. Dirac, while working out a synthesis of the known properties of the elementary particles found another particle – a positive electron – 'jumping off the tip of his pencil'.

Physicists were incredulous until 1932, when Anderson in the USA and Blacket and Occhialini in England photographed this 'anti-particle', the positron.

In the same year, 1932, Chadwick discovered the neutron, the existence of which fundamental particle was predicted as far back as 1920 by Ernest Rutherford.

Soon other particles and anti-particles began jumping off the tips of other pencils. In 1930, Pauli predicted the existence of another elementary particle, which, Fermi, Italian style, christened the 'neutrino'. Twenty six years later, in 1956, it was detected by scientists in the USA. And when detected, it was found to co-exist with its opposite, the anti-neutrino.

In 1935, the Japanese physicist Yukawa found it necessary to postulate the existence of a 'meson'. Several varieties of these were detected in 1948.

In 1955, Emilio Segre and his co-workers in the USA detected the anti-proton. In 1956 the anti-neutron was detected. Physicists were, some time ago, chasing 'quarks' and, as a matter of course, 'anti-quarks'.

And so we have a fundamental law in sub-atomic physics, which follows from Dirac's pioneer work, that every particle has its anti-particle, some particles being their own anti-particles.

If, in the Rutherford-Bohr concept of the atom, electrons would be satisfied with playing a decorous game of musical chairs and flirting within their orbits in accordance with the rules of the quantum theory, the Dirac-Fermi-Pauli elementary particles are more amorous, in fact, passionate, and inter-act ceaselessly. They enter into 'wild marriages' (Born), producing pairs of other particles, while annihilating themselves, or committing 'mutual suicide' (Brown) in the process.[93]

We can well imagine the shade of Hegel nodding sagely, 'I told you so!'

*

For a long time, in spite of all the accumulated evidence, Mach and Ostwald clung on to their 'positivism' and refused to believe in the reality of atoms.* (Lenin polemicises against them at length in his *Materialism and Empirio-Criticism.*) Would that they had lived up to August 5th, 1945 to explain to the hapless victims of Hiroshima and of Nagasaki of a few days later, that the atom was a mere 'mental construct'.

Continuity and Discontinuity

We close our discussion with the views of some world-famous scientists.

According to H.A. Lorentz '. . . it is the quantum conditions that hold matter together and prevent it from completely losing its energy in radiation.'[95]

Louis de Broglie says that without discontinuity 'atoms would be unstable and matter could not exist.'[96] And again: 'Reality cannot be interpreted in terms of continuity alone: within continuity we must distinguish between certain individual entities. . .'[97]

The founder of 'wave mechanics', Erwin Schrodinger states that the demand for continuity is 'something quite exorbitant' and that 'Nature herself seemed to reject continuous description'.[98]

From a life-long study of nature, D'Arcy W. Thompson discovered: 'A "principle of discontinuity". . . is inherent in all our classifications whether mathematical, physical or biological . . .'[99]

And the mathematical analyst Dedekind told us long ago: 'If space has a real existence at all, it is *not* necessary for it to be continuous; many of its properties would remain the same even if were it discontinuous.'[100]

Inerita and Activity

Our fundamental premise is that change is universal. But *also* universal is inertia, a fundamental and *active* tendency of all things to avoid or resist change.

Sir Isaac Newton aptly defined inertia as 'the *force* of inactivity.' (*Principia*, I, Definition I.) (Our Italics.)

Engels, in his notes (c. 1878), tentatively described inertia in the

* We have the evidence of Arnold Sommerfeld: 'William Ostwald told me once that he had been converted to atomistics by the complete explanation of the Brownian motion.'[94] (Einstein, 1905).

philosophical sense as '. . . only the negative expression of the indestructibility of motion . . .'[101]

Inertia and activity* are not only 'opposites', they interpenetrate, *inertia gives rise to activity*.

As we shall see, the effort of the activity is to *counter-act* the change.

Mechanics gives us two simple examples: a stretched spring tends to contract; a wound spring tends to unwind.

From Ernst Mach we have the generalization: 'In every symmetrical system every deformation that tends to destroy the symmetry is complemented by an equal and opposite deformation that tends to restore it. In each deformation positive and negative work is done.'[102]

*

Pierre de la Fermat (1608-1665) is credited with the *first* formulation of a 'variational principle', some examples of which we consider below.

He extended his studies of the 'maxima' and 'minima' ('extrema', 'stationary values', or, geometrically speaking, 'turning values') of mathematical functions to give these concepts a physical meaning.

He gave a theoretical key to the laws of propagation, reflection, and refraction of light with his 'Principle of Least Time' (1628-9), which states that light takes the shortest optical path from point to point.**

In Euclidean geometry we have the well-known lemma that the shortest distance between two points in a plane is a straight line. The well-known experimental laws of rectilinear propagation and reflexion follow from the Principle of Fermat and the simple geometrical consideration that light rays can be represented by straight lines. The laws of refraction are slightly more complicated but not difficult and readers are referred to the text-books, e.g. A.S. Ramsay: *Elementary Geommetrical Optics,* Bell, London, 1920, p.

* Some writers, e.g. Worrall, use the term 'motivity'. The Galileo-Newton concept of 'inertia' should not be understood as inertness. (See, inter alia: Einstein and Infeld: *The Evolution of Physics*; R.L. Worrall: *Energy and Matter*, Ch. III; D'Abro: *The Rise of the New Physics*, Dover 1951, Vol. I, Ch. 18.)

* *Fermat, pioneer in many branches of mathematics: the theory of equations, analytical geometry and the calculus, failed to pubnlish and left us his important and germinal ideas in his correspondence and in marginal notes in books. His idea of 'least time' came to light with the posthumous publication of his *Litterae ad P. Mersenum contra Dioptricam Cartesianum* (Paris, 1687).[103]

126; H.Levy: *Modern Science*, H. Hamilton, London, 1939, p. 320 et seq. Sec. 7.

★

'Isoperimetric' problems, e.g. finding the figure with the maximum area for a given perimeter, and, conversely, finding the figure with the least perimeter for a given area, have been with us since the time of the Greeks, who knew that the answer to both problems was a circle.

According to legend, Dido, a Phoenician princess, shipwrecked on the coast of North Africa, asked the natives to grant her as much land as would be covered by the hide of an ox. When her request was granted she cut the hide in such a way that it would extend into a long thong with which she is said to have enclosed enough land to build the city of Carthage.

Dido laid out her boundary in the shape of an arc of a circle, and her intuition was correct.

The mathematics of the problem, however, are very complicated, and the solutions came many thousands of years later, in fact, after 1696, an important year in the history of mathematics.[104]

Closely related are the problems of shortest distances, 'geodesics', and the lines of quickest descent, 'brachistochrones'.

In 1696, Johann Bernouilli posed, and along with other eminent mathematicians solved, the problem mathematically and laid the foundations for the mathematical study of variations.

With the work of Euler (1707-1783) this became an entirely new branch of mathematics – the Calculus of Variations.*

Stones roll downhill; water flows from higher levels to lower.

In 1644, Evangelista Torricelli (1608-1647) realized that when the 'centre of gravity' of a system was at its lowest, the system would be stable. This idea was given rigorous proof by Lagrange in his pioneer work Mecanique Analytique (1788).[105]

It is a 'universal principle' and a 'fundamental theorem' in analytical mechanics that the position of stable equilibrium or rest of a system is that of the least potential energy.[106]

The determination of the shape of a hanging chain is a rather complicated mathematical problem.

The great Galileo thought, (1638) wrongly, as it turned out, that the shape was that of a parabola.

* Euler's *Traite des Isoperimetres* is dated 1744.

The correct answer was worked out by James and John Bernoulli, Huyghens and Leibnitz (c. 1690) who found it was a catenary.*[107]

On the other hand, the physics of the problem is simple. The chain so hangs that its 'centre of gravity' is at its gravitational lowest.[108]

*

Once the solution to the statical problem was found, it was natural that scientists should look for its dynamical analogue. As Max Planck has noted, in science, 'analogies are seductive'.[110]

Maupertuis (1698-1759) propounded the idea that economy is inherent in nature and therefore, is reflected in all physical laws.

According to his 'Principle of Least Action' (1747), a system tends to keep its 'activity' at a minimum. The 'Principle' was, for him, 'a universal law of repose', and the 'summary' of his mathematical work.[111] Unfortunately, he adduced teleological and theological reasons for the 'Principle'. He was severely criticised (Voltaire called him 'Earth flattener') and few contemporaries saw its scientific significance.

D'Arcy W. Thompson, while noting that 'the principle of least action explains nothing, it tells us nothing of causation, yet it illuminates a host of things'[112], traces the idea back to Aristotle's aphorism, 'Nature does nothing in vain', [113] and to Pappus (fl. 4th century) who suggested a 'principle of economy; in nature.[114]

The Italian physiologist Giovanni Alfonso Borelli in his *De Motu Animalum* (1685) wrote: 'The perpetual law of nature is to act with a minimum of labour. . . avoiding in so far as possible, inconveniences and prolixities. .'[115]

His contemporary Newton observed that 'Nature is pleased with simplicity, and affects not the pomp of superflous causes.' (*Principia*, Preface.)

Leibnitz at about the same time spoke of 'the best of all possible worlds.'[116]

Voltaire, Leibnitz's much younger contemporary, seized on the

* From the Latin *catena*, chain. The shape is also that of the profile of a sail under wind (Johann Bernoulli), and the droop of the wrinkles under old folks' eyes (Albert Durer).[109]

phrase and wrote a biting satire and a classic of world literature with his *Candide* (1756).

★

In 1760, Lagrange revived the idea and, following Euler, gave 'The Principle of Least Action' rigorous mathematical form, yet calling it a 'simple and general result of the laws of mechanics.'[117]

The road leads on to other great discoveries, but it has now become steep and suffice it for us for the present to glance at the terrain before turning our attention to other aspects of 'opposition'.

William Rowan Hamilton (1834) and, after him, M.V. Ostrogradsky (1848) generalized the Lagrangian concept of 'Least Action'. In 1900, Max Planck as we have seen, introduced the idea of the discontinuity of energy and the 'quantum of action.'

The idea is there in the work of statistics by Gibbs and, later, Boltzmann in the 19th Century, and in the work of de Broglie and Erwin Schrodinger in the new 'wave mechanics' of the 20th.

★

The principle of economy is used to explain many of the phenomena of 'capillarity' and 'surface tension', the first mention of which was made by the German scientist Segnes in 1751.[118]

Laplace, (*Mecanique Celeste*, Part X, 1806) explained the phenomena by visualizing that the molecules of an inter-face between two different forms of matter, (for example, a liquid/air surface), are subject to a pull downwards and that therefore all surfaces have a 'surface-energy'.

Surface tension is explained by a tendency to 'surface shrinkage'[119], to an attempt to minimize the surface energy, to a 'Principle of Minimal Areas'.[10*]

This also explains the spherical shape of liquid drops and hardened granules of once molten-metal (Hooke, *Micrographia*, 1665).[122]

Not only liquid drops, soap bubbles and balloons but also biological cell walls at the beginning of their formation (L. Errera

* The now accepted definition of 'Action' as a mathematical function with the dimensions of energy multiplied by time is due to Hamilton.

* James Clerk Maxwell, thinking dialectically, suggested the existence of 'negative surface tension', though he could not cite any example.[121]

L'Optimum, 1896, et alia) tend to achieve the shape with the minimum surface for a given volume – which is a sphere.[123]

★

Minimal principles are used to explain many of the phenomena of electricity.

Electricity tends to flow from a higher potential to a lower.

The 'path of least resistance', often used to describe human activity, is also the preferred path of electric currents.

Ohm's experimental law (1826) defining the relation between voltage (V), resistance (R) and the current (i) in an electrical circuit, ($V = iR$), can also be derived theoretically from the 'Principle of Least Heat': a current in a branched circuit so divides itself that the heat produced in the circuit is a minimum.[124]

There are two other important thermo-electrical effects. In 1821, Seebeck found that a difference in temperature of the junctions of a circuit of two dissimilar metals gives rise to an electric current. In 1834, Peltier discovered the inverse effect – a flow of current in such a circuit produces a difference in temperature. And what is significant is that a Seebeck difference in temperature causes a current in a direction *opposite* to a Peltier current.

Arago obtained some beautiful experimental results in 1824. He found that oscillations were damped if a metal sheet was placed under an oscillating agent, even if the sheet was of non-ferromagnetic material like copper. Similarly, a rotating copper disc was 'braked' in a magnetic field.

The theory of 'eddy currents' in explanation of these phenomena came after Faraday's discovery of electro-magnetic induction.

Faraday's 'lines of force', an invaluable aid in visualizing fields, have a tendency to shorten themselves and also to push themselves aside laterally, i.e., to 'undo' themselves.

The inertial aspect of the important phenomena of electromagnetic induction (Michael Faraday, 1831) and self-induction (Joseph Henry, 1834) was summed up, dialectically, in Lenz's law (1834) that an induced current *opposes* the cause which produces it.

A dramatic experiment illustrates what we may be permitted to call 'electro-magnetic inertia'. A light metallic ring held near an alternating current electro-magnet (that is, in a varying magnetic field) will experience a powerful mechanical resistance. The ring gets

heated up and cannot be held by hand for long. When released, it is flung away.

*

We quote, without discussion, Erwin Schrodinger: 'Einstein's theory is a reduction of gravitation to the law of inertia'.[125] (1916)

*

In chemistry, this phenomenon is recognized in Le Chatelier's principle (1888): if a system in equilibrium is upset by a change of conditions, the system reacts in such a way as to *undo* the effects of the change.

*

Physiology has given us the theory of the 'reflex arc'. The reaction of living tissue to a stimulus is such that the further excitation by the stimulus is avoided: one involuntarily drops a hot plate, or reacts, again involuntarily, to blinding light by blinking or shutting one's eyes.

It is the inertia of the eye, 'persistence of vision', according to the physiologists, that enables us to see motion pictures.

In 1873, Fechner gave us his physiological principle of the tendency to stability according to which the organism tends to keep tensions at a minimum (or constant) as an increase of tension is felt as pain and a decrease as pleasure.

Clinical experience made Freud accept this principle in the field of psychology. He wrote: 'Instinct in general is regarded as a kind of elasticity of living things, as impulsion towards the restoration of a situation which once existed but was brought to an end by some external disturbance.'[126]

Freud's 'Pleasure Principle', so often misrepresented and misunderstood, is nothing other than a principle of least energy.

Freud also conceived of a 'death instinct', the tendency of all organisms to attain the lowest possible level of energy.

*

Inertia causes activity in the social behavour of men. Human beings are fundamentally conservative, weighed down by tradition, and kept in subjection by various forces, not the least of which, as Trotsky pointed out, is 'the force of habit'.[127]

In his 'Letter on Tactics' (April, 1917), Lenin reminded the

Bolsheviks that 'the bourgeoisie maintains itself *not* only by force but also by virtue of the lack of class consciousness, the clinging to old habits, the browbeaten state and lack of organization of the masses.'[128]

In 1920, he reminded the Party again that the power of the bourgeoisie 'lies' not only in the strength of international capital,. . . but also in the *force of habit*. . .'[129]

Trotsky observed that this very characteristic gives rise to progress: 'As a general rule man strives to avoid labour. Love for work is not at all an inborn characteristic: it is created by economic pressure and social education. One may even say that man is a fairly lazy animal. It is on this quality, in reality, that is founded to a considerable extent all human progress; because if a man did not strive to expend his energy economically, did not seek to receive the largest possible quantity of energy, there would have been no technical development or social culture. It would appear, then, from this point of view that human laziness is a progressive force.'[130]

Determinism and Probability*

At the dawn of history, the Chaldeans, after many years of observation, discovered regularities in the motion of heavenly bodies. We may now smile at their cosmogony, but their observations were undoubtedly correct and useful.

Basing his calculations on the Chaldean 'laws', Thales was able to *predict* the eclipse of the sun in 585 B.C.

The Greeks left us a small legacy of scientific laws: the law of reflexion of light (Euclid), the laws of the lever and the law of flotation (Archimedes).

Centuries later Kepler gave us the laws of planetary motion (1609), and Galileo the law of falling bodies and the motion of projectiles (published 1632).

Newton, in his masterly synthesis, *Principia*, 1687, showed that the same laws of motion applied to both celestial and terrestrial phenomena, that, as far as gravitation was concerned, planets were no different from apples.

The concept of determinism came from the French materialists

* This topic is discussed by Engels in *The Dialectics of Nature*, ('Chance and Necessity'), Moscow Edition, 1964, p. 221 et seq.

to the physical sciences[131] and with the work of Descartes and Newton began to dominate them.

Laplace, in a famous passage, declared the confidence of the early 19th Century in the 'Cartesian ideal'[132] that, given the initial conditions and the laws of motion, *all* events are predictable:

> We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at any given moment knew all the forces that animate nature and the mutual position of the beings that compose it, if this intellect were vast enough to submit its data to analysis, could condense into a single formula the movement of the greatest bodies in the universe and that of the lightest atom; for such an intellect nothing would be uncertain, and the future, just like the past, would be present before its eyes.[133]

*

On January 1st, 1801, the Italian astronomer Joseph Piazzi discovered Ceres, the first observed asteroid, one of the minor planets that have their orbits between those of Mars and Jupiter. It was soon 'lost', but Gauss was able to predict its position as it emerged from behind the sun.

In 1781, William Herschel had recognized a new planet in the heavens and named it Uranus.* Differences between the predicted and observed positions of this planet led, in 1845, to the prediction of the existence *and location* of another planet by John Adams in England, and independently, by U.J.J. Leverrier in France. It was first sighted by Galle in Germany in 1846 and named Neptune.

Finer observations indicated that Neptune alone could not account for the irregularities of the orbital movement of Uranus. In our century, Percival Lowell of the USA predicted the existence of the ninth planet which was photographed by Clyde W. Tombaugh in 1930, after Lowell's death and named Pluto.

As Schrodinger has noted with regard to determinism, '. . . when applied to celestial bodies this theory has been triumphantly confirmed.'[134]

*

Ironically, the very scientists who established the concept of

* After Urania, the Muse of Astronomy.

determinism also laid the foundations of the study of the laws of chance, or random, effects.

Many great names are associated with work in this field. We cannot name them all, we mention a few.

Galileo (1564-1642), who studied not only the motion of cannon balls, but also the fall of dice, wrote what was probably the first paper on 'probability'.

In their correspondence on the games of chance, Pascal (1623-1662) and Fermat (1601-1665) summed up, on a mathematical basis, all the previous work on the subject.

Huyghens (1629-1695) made his contributions. Newton (1642-1727) suggested the possibility of explaining macroscopic phenomena by a molecular theory of matter.

In 1693, Edmund Halley (1656-1705), after whom the famous comet is named, studied the statistics of mortality.

*

No one can predict, scientifically, when an individual will die. But statistics indicate what percentage of a given population will be dead at a given point in time.

*

Jacques Bernouilli (1654-1705) in his *Ars Conjectandi* posthumously published, (1713) hinted at the existence of 'a law of large numbers', and its possible applicability to social phenomena.

Abraham de Moivre (1667-1754) who had already written his *Doctrine of Chances* (1718), discovered (c. 1721, published 1733) 'the normal distribution curve', a technical term for a probability graph.

S.D. Poisson (1781-1840) gave us an explicit formulation of 'the law of large numbers' in his *Researches* (1837), calling it 'a universal law': the larger the sample ('ensemble'), the less the deviation from the mean.[135]

Laplace, as we have seen, a convinced spokesman for determinism, independently discovered 'the normal distribution curve', and applied it to mathematical as well as physical problems. The quotation on determinism we have used above comes, in fact, from his *Essai philosophique sur les probabilites* (1846).

The Belgian astronomer L.A.J. Quetelet (1796-1874) pioneered (c. 1835) the use of statistics in the study of human stature and was perhaps the first to use statistical curves (1846).[136]

Gauss (1777-1855) developed the mathematics of the application of statistics to astronomical observations and discovered a distribution curve named after him.

Thus scientists established that there is some 'order' in seeming chaos, and vice versa; that there are statistical or collective truths.

James Clerk Maxwell has given us a graphic example: 'We cannot do better than observe a swarm of bees, where every individual bee is flying furiously, first in one direction and then in another, while the swarm as a whole is either at rest or sails slowly through the air.'[137]

Other examples of 'statistical shapes' are flames[138], clouds[139], jets of water[140], fountains and waterfalls, piles of sand and heaps of grain, smoke from a chimney or funnel, or for that matter, from a cigar or cigarette.

On the astonomical scale we have the shapes of solar flares and of the distant nebulae.

A famous case in the history of science is that of Saturn's rings.

Galileo, who unravelled many astronomical riddles, could not, to the end of his days, with his weak telescope and also his poor eyesight, explain what he described as 'ears' of Saturn.

It was Huyghens who first saw and described the rings of Saturn.

Maxwell proved, mathematically, that the rings could not be solid, but had to be constituted of myriads of fragments.

*

It was, and is, of course, manifestly impossible to write down, leave alone solve, all the determinist equations of motion for a myriad of molecules.

An entirely new approach was necessary.

This was found (c. 1859) by the genius of James Clerk Maxwell. In the words of G.P. Thomson, Maxwell 'was the first to see the possibility of extracting order from the chaos. He proved mathematically that just *because* the motions and collisions are random the distribution of energy among the particles is definite and can be calculated.[141]

The apparent aimlessness of individuals (molecules, water droplets, bees) is compensated for – to satisfy the scientists and to be more exact, is 'swamped' – by the fact that the system as a whole is subject to its own laws.

Max Planck called statistics the study of 'wholesale effects', and de Broglie that of 'en masse phenomena'.

Max Born has claimed that 'all laws of nature are really laws of chance. . .'[142]

His emphasis should have been on the word *law*.

Hyman Levy has expressed the idea better: 'There is *diversity* in detailed behaviour coupled with *uniformity* in mass behaviour';[143] 'a basic randomness builds up to a systematic law. . .'[144]

★

Sir Francis Galton*, who spent a lifetime in the study of statistics, concluded in his *Natural Inheritance* (1889):

> 'I know of scarcely anything so apt to impress the imagination as the wonderful form of cosmic order expressed by the 'Law of Frequency of Error'. The law would have been personified by the Greeks and deified, if they had known it. It reigns with serenity and in complete self-effacement amidst the wildest confusion. The huger the mob and the greater the apparent anarchy, the more perfect its sway. It is the supreme law of Unreason. Whenever a large sample of chaotic elements are taken in hand and marshalled in the order of their magnitude, an unsuspected and most beautiful form of regularity proves to have been latent all along.'[145]

Galton has described for us what is called his 'toy', a device that dramatizes the Gaussian distribution: if sand is poured from the top of a sloping tray studded with equally spaced pins, the 'bell shaped curve' develops as we watch.**

★

All of us have seen the haphazard motion of smoke or dust particles in sunbeams. Robert Brown, a Scottish botanist, in 1827, drew the world's attention to the random motion of pollen grains in water. This was explained by Christian Wiener (1863) as a phenomenon of molecular bombardment, and in 1905, Einstein and,

* The name of Sir Francis Galton (1822-1911), explorer, naturalist and statistician, grandson of Erasmus Darwin, has been eclipsed by that of his more famous cousin. His work deserves better publicity and study. He was an advocate of 'eugenics', a word which he coined. In an article entitled 'Psychometric Experiments' (*Brain*, July 1879) he described his method of recording 'associated ideas' and set out his discovery of the phenomenon of what is now known in psychoanalytic terminology as 'resistance'. As was to be expected, he applied statistics to his 'associated memories' and found that 39 per cent of them related to his childhood events. (Sigmund Freud was an undergraduate at the time.)[146]

**There is a detailed discussion of the curves of error in Thompson's *Growth and Form* (p. 118 et seq.) and a self-explanatory diagram of Galton's 'toy' in Levy's *Modern Science*, (p. 636)

independently, Smoluchowski derived a statistical explanation.

The study of 'radio-activity' at the turn of our century has given us the concept of radio-active 'half life': we cannot predict which atom of a radio-active element will disintegrate at a given moment, but we can say, for example, that half the atoms of Uranium will decay in 4500 million years.

*

Statistics and the mathematics of probability are now indispensable tools in the scientific study of natural and social phenomena.

We mention the names of that unsung American genius Josiah Willard Gibbs; of Ludwig Boltzmann who placed the Clausius-Helmholtz Second Law of Thermodynamics on a statistical basis; of Einstein and Bose, of Fermi and Dirac who applied statistics to sub-atomic particles. A discussion of their work is beyond the scope of this work.

Werner Heisenberg and Erwin Schrodinger were compelled to use the concept of probability in their work on 'wave mechanics'. In the words of the latter: 'And so we have the paradox that, from the point of view of the physicist, chance lies at the root of causality . . .'[147]

*

Way back in 1813, Hegel gave the solution to the 'paradox.' In Engels' words: 'Hegel came forward with the hitherto unheard of propositions that the accidental has a cause because it is accidental, and just as much also has no cause because it is accidental; that the accidental is necessary, that necessity determines itself as chance, and, on the other hand, this chance is rather absolute necessity.'[148]

In his *Wage Labour and Capital*, Marx, referring to the price of commodities, pointed out that '. . . the total movement of this disorder is its order.'[149]

In *Capital*, he wrote: 'The division of labour within the society brings into contact independent commodity producers, who acknowledge no other authority but that of competition, of the coercion exerted by the pressure of their mutual interests; just as in the animal kingdom the *bellum omnium contra omnes** more or less preserves the conditions of existence of every species.'[150]

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* *Bellum*. . . 'The condition of man. . . is a condition of war of everyone against everyone.' Thomas Hobbes (1588-1679), *Leviathan*, 1651.

He also observed that under capitalism, 'inherent laws impose themselves only as the mean of apparently lawless irregularities that compensate one another.'[151]

Engels discussed the subject in his *Ludwig Feuerbach* (1886) where he wrote of 'the regularity inherent in accidents. . .'[152] '. . . in nature and also up to now for the most part in human history, these laws assert themselves unconsciously, in the form of external necessity, in the midst of an endless series of seeming accidents. . .'[153]; '. . . thus the conflicts of innumerable wills and individual actions in the domain of history produces a state of affairs entirely analogous to that prevailing in the realm of unconscious nature. Historical events thus appear on the whole to be likewise governed by chance. But where on the surface accident holds sway, there actually it is always governed by inner, hidden laws, and it is only a matter of discovering these laws'.[154]

In the concluding section of *Origin of the Family. . .* (1888) Engels wrote: 'But chance is only one pole of an interrelation, the other pole of which is called necessity. In nature, where chance also seems to reign, we have long ago demonstrated in each particular field the inherent necessity and regularity that asserts itself in this chance. What is true of nature holds good also for society. . .'[155]

In his correspondence Engels explained (1890): '. . . Thus there are innumerable intercepting forces, an infinite series of parallelograms of forces which give rise to one resultant – the historical event. This may itself be viewed as the product of a power which works as a whole *unconsciously* and without volition. . . Thus history has proceeded hitherto in the manner of a natural process and is essentially subject to the same laws of motion. . .'[156]

Lenin, in his summary of Marxist economics, wrote: 'It is quite natural that in a society of separate producers of commodities, who are united only by the market, a conformity to law can be only an average, social, mass manifestation, with individual deviations in either direction mutually compensating one another.'[157]

Trotsky has observed that Marx solved '. . . the fundamental puzzle – how in capitalist society, in which each man thinks for himself and no one thinks for all, are created the relative proportions of the various branches of economy indispensable to life.

'The worker sells his labour power, the farmer takes his produce to the market, the money lender or banker grants loans, the

store-keeper offers an assortment of merchandise, the industrialist builds a plant, the speculator buys and sells stores, stocks and bonds – each having his own considerations, his own private plan, his own concern about wages or profit. Nevertheless, out of this chaos of individual strivings and actions emerges a certain economic whole which, true, is not harmonious, but contradictory, yet does give society the possibility not merely to exist but even to develop. This means that, after all, *chaos is not chaos at all*, that in some way it is *regulated automatically*, if not consciously. . .'[158] (Our italics).

Truth and Error

We have seen that scientific laws are limited generalizations.

'Truth and error,' Engels pointed out, 'like all concepts which are expressed in polar opposites, have absolute validity only in an extremely limited field.'[159]

Every truth, in so far as it is limited, contains error. Engels commented on this thesis of Hegel:

> 'Truth, the cognition of which is the business of philosophy, was in the hands of Hegel no longer an aggregate of finished dogmatic statements, which once discovered, had merely to be learned by heart. Truth lay now in the process of cognition itself; in the long historical development of science, which mounts from lower to ever higher levels of knowledge without ever reaching, by discovering so-called absolute truth, a point at which it can proceed no further, where it would have nothing more to do than to fold its hands and gaze with wonder at the absolute truth to which it had attained. . .'[160]

To quote Hegel himself: 'The more the ordinary mind takes the opposition between true and false to be fixed, the more it is accustomed to expect agreement or contradiction with a given philosophical system, and only to see reason for the one or the other in any explanatory statement concerning such a system. It does not conceive the diversity of philosophical systems as the progressive evolution of truth; rather it sees only contradiction in the variety.'[161]

In his preface to Marx's *The Poverty of Philosophy* (1884), Engels made an interesting observation: 'But what formally may be economically incorrect, may all the same be correct from the point of view of world history. . .'

Formal Logic

Classical, Aristotelean logic takes as its fundamental premise *the Law of Identity,* the statement that a thing is identical with itself. Expressed in a formula: A is A.

Its negative form, *the Law of Contradiction* states that a thing is never different from itself, that A is not and cannot be non-A.

In combination, these laws give rise to a third, *the Law of the Excluded Middle.* Either A is B, or it is non-B; it cannot be both.

These three laws of formal logic, which Aristotle made the basis of his system, had a tremendous significance in the history of human thought, just as specific formulations were of great importance in the various branches of science.

Way back in the mists of time man must have realized that it is the same sun that rises every day, but there was a Red-Indian folk tale that a new sun rises every day, while the old ones collect at the bottom of the sea.

Astronomy took a leap forward when Pythagoras realized that the 'Morning Star' and the 'Evening Star' were different positional appearances of the planet Venus.[162]

Chemistry was placed on a new basis with the discovery of the Law of Conservation of Matter, that matter cannot, in all its combinations and dissociations, be created or destroyed. (Lomonosov 1756, Lavoisier 1774). Proust's Law of Constant Composition, that chemical compounds are identical, no matter how they are obtained, is only a chemical formulation of the Law of Identity: A is A.[163]

Physics and physiology opened up new horizons with the formulation of the equivalence of heat and energy (Rumford 1798, Joule 1843) and the Law of Conservation of Energy (Mayer 1842, Helmholtz 1847).

Classification in biology (from Aristotle to Linnaeus) is nothing other than the application of the Law of Identity.

William Warde does not exaggerate when he writes:

> We could neither act nor think correctly without consciously or unconsciously obeying this law. If we could not recognize ourselves as the same person from moment to moment and from day to day – (and there are people who cannot, who through amnesia or some other mental disturbance have lost their

> 'consciousness of self-identity) – we would be lost. But the law of identity is no less valid for the rest of the universe as for human consciousness. It applies everyday and everywhere to social life. . .
> . . . All science as well as all intellectual behaviour rests in part upon this law of identity.
> 'The law of identity directs us to recognize likeness amidst diversity, permanence amidst changes, to single out the basic similarities between separated and apparently different instances and entities, to uncover the real bonds of unity between them, to trace the connections between different and consecutive phases of the same phenomena.[164]

We have already seen, however, that all of existence is the unity of opposites, and that Zeno demonstrated the breakdown of the law of identity when applied to motion: either the arrow is there or it is not there.

Plekhanov in his delightful essay *Dialectic and Logic* [165] and recently William Warde in his detailed study *An Introduction to the Logic of Marxism* [166] have, following Hegel, shown the limitations of the laws of formal logic.

Briefly, the laws of formal logic are applicable, firstly, within specific limits, and secondly, on condition that there is continuity, in other words that there is no change.

Knowing that change is universal, we see immediately that despite their usefulness and importance, the laws of formal logic have an extremely limited range of validity.

It was Hegel who was responsible for the modification of the laws of logic that enlarged the range of their validity and made possible their applicability to changing phenomena. He transformed logic into a dynamic science and called it *dialectics*.

Identity and Difference

For Aristotle, identity excludes difference. With Hegel identity and difference are a unity.

In Aristotle's formal logic A is A, and never non-A. In Hegel's dialectics A is A as well as non-A.

Thus, as Otto Ruhle pointed out, whereas the old logic stated 'Everything is identical with itself, nothing contradicts itself', Hegel counter-posed: 'Nothing is identical with itself, and everything contradicts itself.'[167]

Hegel criticized the old logic: 'The thinking of this metaphysics was not free and true in the objective sense, as it did not leave it to the object to develop freely out of itself and itself find its definitions, but took it as something ready-made. . . This metaphysics is dogmatism, because, in accordance with the nature of final definitions, it had to assume that, of two antithetical assertions. . . one was necessarily true, and the other necessarily false.'[168]

Contrasting his dialectics, Hegel wrote: 'Instead of speaking by the maxim of the Excluded Middle (which is the maxim of abstract understanding), we should rather say: Everything is opposite. Neither in heaven nor on earth, neither in the world of mind nor of nature, is there anywhere such an abstract 'either-or' as common sense thought maintains. *All that is, is concrete, with difference and opposition within itself.*'[169] (Our italics)

Hegel ridiculed the old logic: 'It is asserted that the maxim of identity, though it cannot be proved, regulates the procedure of every consciousness, and that experience shows it to be accepted as soon as it is apprehended. To this alleged experience of the logic books may be opposed the universal experience that no mind thinks or forms conceptions or speaks, in accordance with this law, and that no existence of any kind whatever conforms to it. Utterances after the fashion of this pretended law (A planet is a planet; magnetism is magnetism; mind is mind) are, as they deserve to be, reputed silly.'[170]

Hegel pointed out that every ordinary statement does not take the form A is A (a man is a man) but in fact contains concrete truth and takes the form A is B (man is mortal) and implies the unity of identity and difference.[171]

Gertrude Stein's 'A rose is a rose is a rose . . .' may be good poetry, but as a statement of identity, is, to use Hegel's phrase, 'insufferably vacuous.'[172]

Marx commented: 'It is typical of bluff commonsense that where it manages to see difference, it does not see unity, and where it sees unity, it does not see difference. If perchance, it sets up distinguishing qualities, it immediately petrifies them. . .'[173]

Engels noted that 'Abstract identity, with its opposition to difference, is in place only in mathematics – an abstract science which is concerned with creations of thought. . .'

He agreed with Hegel that every time one says 'John is a man', or 'the lily is a plant', or 'the rose is red', that is, every time the

singular is equated to the general, 'where the predicate is necessarily different from the subject,' 'the fact that identity contains difference within itself is expressed in *every sentence*. . . That from the outset *identity with itself* requires *difference from everything else* as its complement, is self-evident.'[174]

'. . . Most natural scientists imagine,' Engels complained, 'that identity and difference are irreconcilable opposites, instead of one-sided poles which represent the truth only in their reciprocal action, in the inclusion of difference *within* identity.'[175]

Writing in lighter vein to Conrad Schmidt, Engels gave a down-to-earth example of the unity of identity and difference:

> 'For instance, you as a bridegroom, have a striking example of the inseparability of identity and difference in yourself and your bride. It is absolutely impossible to decide whether sexual love is pleasure in the identity in difference or in the difference in identity. Take away the difference (in this case of sex) or the identity (the human nature of both) and what have you got left?'[176]

We can readily agree with Engels – the maleness of man would be meaningless without woman; the opposite sexes are mutually complementary, and are composite sub-divisions of Man.

The Unity of Opposites

W.T. Stace, in his excellent commentary on the philosophy of Hegel, summed up this aspect of dialectics:

> 'Hegel's audacity and originality consists simply in this, that he explained and showed in detail how it is logically possible for two opposites to be identical while yet retaining their opposition. . . If we can only say A is A, the infinite is the infinite, then A must remain A forever, the infinite must remain infinite, and therefore sterile within itself, for ever, and the finite world can never arise out of it. We can only solve this problem if the infinite contains the finite, just as being contains non-being, if the infinite *is* the finite, if A is non-A.
>
> 'It is of paramount importance to observe that the identity of opposites does not exclude the opposition of those opposites. A and non-A are identical. But they are also distinct. It is not only an *identity* of opposites, it is also an identity of *opposites*. The opposition is just as real as the identity.'[177]

Stace adds that Western thinkers stress differences and ignored

identity – they said A is not non-A. Indian thinkers (Vedanta) stressed the identity and ignored the differences – they said A is A. Hegel said A is non-A.[178]

While recognizing polarity, Hegel emphasized that the poles are '*inseparably* distinguished.'[179]

Engels wrote: 'Closer investigation shows us that the two poles of an antithesis, like positive and negative, are just as inseparable from each other as they are opposed, and that despite all their opposition they mutually penetrate each other. . .'[180]

In contrast to dialectics which sees the co-existence, the unity and interpenetration of opposites, metaphysics provides us with empty abstractions.

Engels criticised the metaphysicians:

> To the metaphysician, things and their mental reflexes, ideas, are isolated, are to be considered one after the other and apart from each other, are objects of investigation, fixed, rigid, given once for all. He thinks in absolutely irreconcilable antitheses. . . For him a thing either exists or does not exist; a thing cannot be at the same time be itself and something else. Positive and negative absolutely exclude one another; cause and effect stand in rigid antithesis one to the other.[181]

He repeated the same point in his letter to Conrad Schmidt:

> What these gentlemen all lack is dialectics. They always see only here cause, there effect. That this is a hollow abstraction, that such metaphysical polar opposites exist in the real world only during crises, while the whole vast process goes on in the form of an interaction, though of very unequal forces, the economic movement being by far the strongest, most primeval, most decisive – that here everything is relative and nothing absolute – this they begin to see. Hegel has never existed for them.[182]

'Dialectics,' wrote Lenin, 'in the proper sense is the study of contradiction *in the very essence of objects*; not only are appearances transitory, mobile, fluid, demarcated only by conventional boundaries, but the essence of things is so as well.'[183]

Lenin noted that, according to Hegel, thinking dialectically means 'comprehending the antithesis in its unity. . .'[184]

In brief,' he said, 'dialectics can be defined as the doctrine of the unity of opposites.'[185]

'The division of the one and the cognition of its contradictory

parts. . . is the essence (one of the 'essentials', one of the principal characteristics or features) of dialectics.'[186]

We can appreciate the genius of Heraclitus who, some two thousand three hundred years ago, declared that *Opposition* is the ruling principle of the universe.[187] Everything is a balance of, and a battleground for, opposing forces.[188] 'Difference is the essence of harmony.'[189]*

*

Let us now make our survey brief. We have to pass on.

In chemistry we have the opposite processes of oxidation-reduction, catalysis-inhibition, analysis-synthesis, exothermy-endothermy, and so on.

In the electrolytic apparatus we have the electrodes described (Faraday) as anode (positive) and cathode (negative); in the ionic theory of Svante Arrhenius, an-ions and cat-ions, positive and negative.

In nuclear physics there are the now, unfortunately, well known phenomena of fission and fusion.

Botanists tell us that all the phenomena of plant physiology are governed by opposing principles: phototropism (or heliotropism), the growth of the shoot of the plant towards light, is complemented by the anti-phototropism (apheliotropism) of the root, a tendency to grow away from light; geotropism, the growth of roots towards the pull of gravity is opposed by a negative or anti-geotropism on the part of the shoot, hydrotropism, the roots' attraction towards water has its opposite tendency on the part of the shoot; haptotropism, the tendency of roots to avoid hard substances is complemented by the tendency of climbing stems to twine round hard objects.

Leaving the apparent exceptions aside, it does not require much observation or imagination to realize that, without these 'opposite' tendencies, no plant can grow.

In histology we have the polarity of cells, which is most marked in embryonic and regenerative cells. **

* We have seen (p.61) that the concept of opposites goes back to Anaximander. Pythagoras also recognized the existence of opposites, but he hastened to harmonize them by seeking a 'mean'. (See George Thomson: *Aeschylus and Athens*, Lawrence and Wishart p. 210).

**This topic is discussed at length and with authority by D'Arcy W. Thompson in *Growth and Form*, p. 282 et seq.

In 1874, Brucke declared his confidence that physiological forces would with further research be ultimately reduced to two: attraction and repulsion.[190]

In the physiological study of response to stimuli we come across excitation and inhibition.

Ivan Pavlov has told us that, 'These two processes, it is necessary to add, are co-existent and equally important in the nervous activity.'[191]

The list is inexhaustible, and this is, perhaps, a convenient point to stop.

*

If we have, despite Mephistopheles' advice, 'ranged from science to science,' it has not been 'in vain'.[192]

In every phenomenon we have studied we have found, after Heraclitus and Hegel, the existence of and the unity of opposites.

Discussing the situation in his special branch of physics, Erwin Schrodinger wrote, in *1935*:

> We are confronted with the profound logical anti-thesis between
> Either this or that (*aut - aut*) (Particle mechanics),
> This as well as that (*et - et*) (Wave mechanics.)'[193]

*

Sixty years earlier, in *1875*, Engels in his (unpublished) studies had noted:

'Dialectics, which likewise knows no hard and fast lines, no unconditional, universally valid '*either - or*' and which bridges the fixed metaphysical differences, and besides '*either - or*' recognizes also in the right place '*both this - and that*, and reconciles the opposites, is the sole method of thought appropriate in the highest degree to this stage.'[194]

It was perhaps philosophical intuition that made Schiller warn the philosophers and the scientists:

'Be ye opponents! The time is not ripe to join hands:
Only on different roads will you come to the truth.'[195]

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Chapter Seven

Development through Contradiction

Truth through Conflict

The word 'dialectics' is derived from the Greek adjective 'dialektike' – argumentative.*
Socrates, sometimes described as 'an intellectual midwife', is said to have perfected the method of reaching for the truth through debate, discourse and disputation.

A proposition would be contradicted and a new proposition reached in the union between the original proposition and the contradiction. The new proposition would, in turn, be contradicted, leading to a closer approximation to the truth.

Long ago, the poet Goethe observed that the solution to any problem contained a new problem.[1] In recent times, the scientist Max Planck pointed out that '. . . the solution of one problem only unveils the mystery of another.'[2] Niels Bohr often told his students: 'Every sentence I utter is to be understood as a question and not as an affirmation. . .'[3]

The process is best summarized in Fichte's formula:

Thesis – Antithesis – Synthesis.

The Synthesis – *Its* Antithesis – A higher Synthesis, and so on.[4]

Marx, in a similar word-play, said that dialectics reached

* We are grateful to the late Dr. George Wickremanayake who informed us that 'dialektike' is a feminine adjective generally agreeing with 'techne' (art, craft or science).

towards the truth by 'proposing', 'opposing' and 'composing' the differences.[5]

Lessing once observed: 'Truth has gained from every controversy.'[6]

In one of his early writings, Marx pointed out: 'Not only the result but also the road to it, is part of the truth. The investigation of truth must itself be true, true investigation is unfolded truth, the disjuncted members of which unite in the result'.[7]

Lenin often repeated: 'Truth is a process'.[8] One of his favourite quotations, according to N.K. Krupskaya, was the French proverb: 'Truth is a consequence of conflicting opinions.'*[9]

Marxism recognizes no other way of reaching for the truth. It has no place for inspired revelations claiming to be the final word on all matters. In fact, Marx criticized the 'doctrinaires' who would say in effect: 'Here is the truth: Kneel before it.'[10]

Trotsky wrote in reference to a specific situation:

'There is no book which sets in advance the correct orbit for the first workers' state. The head does not and cannot exist which can contain the ready-made formula for socialist society. The roads of economy and politics must still be determined only through experience and worked out collectively, that is, through a constant conflict of ideas.'[11]

The Cause of Change

It is not only in the field of ideas that change is brought about by contradiction.

The whole of Nature moves forward through this process.

At a very early stage of his intellectual development man recognized that external causes or agencies could produce effects or changes. In fact, the first act of early man that was not motivated by instinct implied a recognition of this principle. (Animal psychologists may claim the same power for their subjects, but let us not digress.)

It was not long before attempts were made to define the connection between cause and effect.

Let us take a gigantic leap across the history of human thought

* In this connection we cannot help recalling Mark Twain's comment that it is difference of opinion that makes horse races.

and examine one of the most important scientific formulations of such a relationship.

Classical mechanics rests on the formulations of Sir Isaac Newton (*Principia*, 1687), the first of whose laws of motion defines force as the external agency that causes acceleration, a change in the state of rest or uniform linear motion of a body.

In such views of development, the cause of change is *external*.

By counter-opposing force and acceleration as cause and effect, Newton arrived at a simple law of motion (the Second) which states that force is equal to mass multiplied by acceleration.

This is now recognized as 'the fundamental theorem of dynamics,'[12] and has proved to be supremely important in the investigation of the physical world.

It is a milestone in the history of science.

★

Hegel criticized Newton's view. He insisted that what was separable in thought was not separable in nature. To quote him on the subject of Newton's Laws: 'Such separation of external and essential motion belongs neither to experience nor to the motion, but only to abstracting reflexion. It is one thing to distinguish them, as is necessary, as well as to characterize them mathematically as separate lines, to treat them as separate quantitative factors, and so on – it is another thing to regard them as physically independent existences.'[13]

Commenting on Thales' views, Hegel wrote: 'It is better to say that a magnet has a *soul*. . . than that it has an attracting *force*; force is a kind of property. . . *separable from matter*. . . while soul. . . *is this movement itself, identical with the nature of matter*.'*[14]

★

Hegel was obviously unaware of the dialectical formulation of Newton's Law by d'Alembert in his *Treatise on Dynamics* (1743).

Taking Euler's formulation of Newton's Second law: $P = \mathrm{m}\,f$, (force P equals mass m multiplied by acceleration f) where P and f are vectors (directed quantities), d'Alembert transposed mf and

* 'Having a soul' is better rendered as 'animated'.

wrote: $P - mf = 0$. Expressing $-mf$ by I, a *negative* vector, Newton's law was written: $P + I = 0$.[15]

*

It was Hegel's immortal merit that he drew attention to the fact that changes are brought about by the *inner contradictions* of a system, that all things, by virtue of *the inherent unity of opposites* are destined to *self-movement* and *development*.

*

This idea is not only pre-Hegelian, but ancient.

The Roman poet, Ovid (43 BC - 17 AD) pronounced: 'Every shape that is born bears in its womb the seeds of change'.

Benjamin Franklin (1706-1790) wrote: '. . . every animal brings into the world among its original stamina the seeds of that disease that shall, finally produce its dissolution. . .'[16]

Contradiction

Hegel pointed out that the co-existence, the unity, the inter-penetration of opposites constitutes an inner and inherent contradiction, a basic instability in all things which leads to development and change.

He said: 'All opposites which are taken as fixed, such as, for example, finite and infinite, or individual and universal, are contradictory, not by virtue of some external connection, but rather are transitions in and for themselves.'[17]

He insisted: 'All things are contradictory in themselves.'[18]

The existence of contradictions in all things gives rise to self-movement.

In his *Encyclopaedia* Hegel wrote: 'Contradiction, above all things, is what moves the world: and it is ridiculous to say that contradiction is unthinkable.'[19]

And again in his *Logic*: 'Contradiction is the root of all movement and vitality, and it is only in so far as it contains a contradiction that anything moves and has impulse and activity.'[20]

Contradiction is 'the principle of all self-movement.'[21]

Concisely: 'Contradiction leads forward.'[22]

That which has no contradiction, according to Hegel, is 'sterile within itself.'[23] 'Abstract self-identity has no vitality.'[24]

In explanation, Hegel wrote: 'Something moves, not because it is here at one point of time and there at another, but because at one and the same point of time it is here and not here, and in this here both is and is not. We must grant the old dialecticians the contradictions which they prove in motion; but what follows is not that there is no motion, but rather that motion is *existent* contradiction.'[25]

One of the old dialecticians Hegel referred to is Zeno. Another is Heraclitus, who, with brilliant intuition maintained that 'Everything happens through struggle' which is the 'father' of all things.[26]

Marx adopted Hegel's concept of inherent contradiction, and acknowledged that: '*The Hegelian Contradiction* (is). . . *the main source of dialectics*.'[27] (Our italics).

He said: 'What constitutes dialectical movement is the coexistence of two contradictory sides, their conflict and their fusion into a new category.'[28]

In answer to the American journalist John Swinton who, in 1880, asked the ageing Marx what he saw in the future, Marx replied: 'Struggle!', summing up in a word, the law of life.[29]

In his drafts for *Anti-Duhring*, Engels noted: 'Antithesis – if a thing is saddled with its antithesis it is in contradiction with itself, and so is its expression in thought. For example, there is a contradiction in a thing remaining the same and yet constantly changing being possessed of the antithesis of 'inertness' and 'change'.'[30]

Having seen that all things are a unity of opposites, we can appreciate that all things are, therefore, self-contradictory, unstable, changing and developing.

'Dialectics,' observed Lenin, '. . . is the study of contradiction *in the very essence of* objects. . .'[31]

Lenin summarized: 'The condition for the knowledge of all proceses of the world in their '*self-movement*', in their spontaneous development, in their real life is the knowledge of them as a unity of opposites. Development is the 'struggle' of opposites. . . the struggle of exclusive opposites is absolute, just as development and motion are absolute. . .'*[32]

Rosa Luxemburg observed: 'Historic development moves in

* Lenin warned, however, that, 'Antagonism and contradiction are by no means the same thing. Under Socialism the first will disappear and the second will remain.'[33]

contradiction, and for every necessity puts its opposite into the world as well. The capitalist state of society is doubtless a historic necessity, but so also is the revolt of the working class against it. Capital is a historic necessity, but in the same measure is its grave-digger, the socialist proletariat.'[34]

★

In 1892, Sigmund Freud set out his discovery of the existence of 'antithetic' ideas that disturbed the conscious activity of the mind.[35]

On the psycho-analytic concept of 'repression', Freud said: '. . . we explain it dynamically, from the conflict of opposing mental forces, and recognize it as the outcome of an active struggling on the part of the two psychical groupings against each other.'[36]

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Chapter Eight

The Self-Transformation of Opposites

Hegel not only showed that contradictions lead to development, he also pointed out that development leads to 'negation', the self-transformation of a phenomenon into its opposite, the self-replacement of one form of existence by its antithesis, the self-suppression of all things.

In his *Encyclopaedia*, Hegel wrote: 'But the essence of the matter is that what is definite is not only limited from without, but is bound to be destroyed and to pass over into its opposite by virtue of its own nature.'[1]

In explanation he said: 'We say, for instance, that man is mortal, and seem to think that the ground of his death is in external circumstances only; so that if this way of looking were correct, man would have two special properties, vitality and – also – mortality. But the true view of the matter is, that life, as life, involves the germ of death, and that the finite, being radically self-contradictory, involves its own self-suppression.'[2]

According to Hegel, this dialectical self-transformation is universal. To quote his *Encyclopaedia* again:

> Wherever there is movement, wherever there is life, wherever anything is carried into effect in the actual world, there dialectic is at work. It is also the soul of all knowledge which is truly scientific.

> Dialectics gives expression to a law which is felt in all grades of consciousness, and in general experience. Everything that surrounds us may be viewed as an instance of dialectic. We are aware that everything finite, instead of being inflexible and ultimate, is rather changeable and transient; and this is exactly what we mean by the dialectic of the finite, as implicitly other than it is, is forced to surrender its own immediate or natural being, and to turn suddenly into its own opposite.[2]

In his *Logic*, Hegel repeated the point:

> The understanding may demonstrate that the idea is self-contradictory, because, for instance, the subjective is only subjective and is always confronted with the objective; that Being is something quite different from the notion and therefore cannot be extracted out of it; and that likewise the finite is only the finite and the exact antithesis of the infinite, and therefore not identical with it; and so on with all the determinations. Logic, however, demonstrates the opposite of all this, namely, that the subjective, which is to be the subjective only, the finite, which is to be finite only, the infinite, which is to be the infinite only, and so on, have no truth, but contradict themselves, and pass into their opposites.[3]

As an example, Hegel pointed out that every abstract justice carried to its logical conclusion becomes an injustice. In illustration, Plekhanov cited 'the pound of flesh' theme in Shakespeare's *The Merchant of Venice*.

The idea goes back to ancient times. Terence (185-159 BC) in *Eunuchus* (Scene IV) has the line: 'Rigorous law is often rigorous injustice.'

We have already heard Juliet's confession. In the same play, we find lines:

'Virtue itself turns vice, being misapplied;
And vice sometime's by action dignified.' (*Romeo & Juliet*, II, iii)

And then there are the oft-quoted lines of William Congreve:
'Heaven has no rage like love to hatred turned,
Nor hell a fury like a woman scorned.'[4]

And from Goethe we have: 'Reason becomes unreason, right wrong.'

It must be emphasized that the Hegelian concept of negation is not artificial or mechanical, not a mere placing of a minus sign before

ERRATUM

We regret that the following passage was omitted from page 95 after the citation from Goethe.

> 'Marx accepted Hegel's concept of negation: 'Any development, whatever its substance may be, can be represented as a series of different stages of development that are connected in such a way that one forms the *negation* of the other. . . In no sphere can one undergo a development without negating one's previous mode of existence'.[5]
>
> In 1873 Marx wrote: 'in its rational form. . . [Dialectics] includes in its comprehension and affirmative recognition of the existing state of things, at the same time also, the recognition of the negation of that state, of its inevitable breaking up'.[6]
>
> Plekhanov emphasized: '. . . every phenomenon, by the action of those same forces which condition its existence, sooner or later, but inevitably, is transformed into its own opposite'.[7]
>
> Lenin pointed out: 'That all dividing lines, both in nature and society, are conventional and dynamic, and that *every* phenomenon might, under certain conditions, be transformed into its opposite, is, of course, a basic proposition of Marxist dialectics.'[8]
>
> In his *Philosophical Notebooks*, he defined this aspect of dialectics: 'Dialectics is the teaching which shows how *Opposites* can be and how they happen to be (how they become) *identical*, — under what conditions they become identical, becoming transformed into one another — why the human mind should grasp these opposites not as dead, rigid, but as living, conditional, mobile, becoming transformed into one another'.[9]'

We also regret that the author's name has been incorrectly spelt in several places and we apologise to him for this error.

a given quality, but a self-transformation of a phenomenon into *its* opposite.

Hegel warned that negation should not be abstract or empty, but that 'the self-contradictory resolves itself not into nullity, into abstract Nothingness, but essentially only into the negation of its particular content.'[10]

Engels, following Hegel, repeated that dialectical negation is not mechanical: 'Negation in dialectics does not mean simply saying no, or declaring that something does not exist, or destroying it in any way one likes. . . If a grain is crushed or an insect killed, *it is not negation* but destruction. . . Each class of things therefore has its appropriate form of being negated in such a way that it gives rise to a development, and it is just the same with each class of conceptions and ideas.'[11]

Self-Transformation

We have seen Tolstoy's man 'becoming unlike himself', when a hidden trait becomes a dominant characteristic.

Error emerges from truth justifying the old saying that the science of one age becomes nonsense in the next.

The reverse is also true. Engels pointed out that '. . . According to an old and well known dialectical law, incorrect thinking, carried to its logical conclusion, inevitably arrives at the opposite point of departure.'[12]

Way back in 1749, Benjamin Franklin observed: '. . . even a bad solution read, and its faults discovered has often given rise to a good one.'[13]

We have the interesting comment of Pareto: 'Give me a fruitful error anytime, full of seeds, bursting with its own corrections. You can keep your sterile truth for yourself.'

*

Pain gives rise to pleasure, love turns into hate.

Freud supported this view from experience: 'Clinical observation shows not only that love is with unexpected regularity accompanied by hate (ambivalence), and not only that in human

relationships hate is frequently a fore-runner of love, but also that in many circumstances hate changes into love and love into hate.'[14]

*

Hegel said: 'We say that all things (i.e., all that is finite as such) must be submitted to the judgement of dialectics and by the very fact we define it as a universal, invincible force, which must destroy everything, no matter how lasting it may seem.'[15]

Plekhanov commented: 'The important thing is that Hegel's view of social phenomena is far more profound than that of people who know only one thing, namely, that *there is no action without cause*. Neither is that all. Hegel brought out a far more profound and more important truth. He said that every particular aggregate of phenomena in the process of its development creates *out of its very self* the very forces that lead to its negation, i.e., its disappearance; that consequently every particular social system, in the process of its historical development, creates *out of its very self* the social forces that destroy it and replace it by a new one.'[16]

We can readily appreciate why the Russian radical Herzen hailed the Hegelian philosophy as 'the algebra of revolution.'[17]

'The negation of living is contained in life itself,' said Engels, supporting Hegel's point that vitality and mortality are not separable phenomena. Recognizing the self-suppressing tendency of life, he said, concisely, 'Living means dying.'[17]

Once more let us pay tribute to Heraclitus of Ephesus, who, with profound intuition, maintained that the basic law of the world is 'the law of transformation into the opposite.'[19]

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Chapter Nine

Negation of The Negation

No negation is, or can be, final. Each negation leads to a new series of opposites, disclosing them, giving rise to their interpenetration and conflict, and these in turn, lead to a new negation. Each negation is thus negated, giving rise to unceasing development and change.

Hegel explained: 'The bud disappears when the blossom breaks through, and we might say that the former is negated by the latter; in the same way when the fruit comes, the blossom may be explained to be a false form of the plant's existence, for the fruit appears as its true nature in place of the blossom. These stages are not merely differentiated; they supplant one another as being incompatible with one another. But the ceaseless activity of their own inherent nature makes them at the same time moments of an organic unity, where they not merely do not contradict one another, but where one is as necessary as the other; and this equal necessity of all moments constitutes alone and thereby the life of the whole.'[1]

From Engels we have another example from plant life: 'Let us take a grain of barley. If such a grain meets with conditions which for it are normal, if it falls on suitable soil, then under the influence of heat and moisture a specific change takes place; it germinates; the grain as such ceases to exist, it is negated, and in its place appears the plant which has arisen from it, the negation of the grain. But what is the normal life process of this plant? It grows, flowers, is fertilized and finally as soon as these have ripened on the stalk, dies, is in its turn negated. As a result of this negation of the negation we have

once again the original grain of barley, but not as a single unit, but ten, twenty or thirty fold.'[2]

Engels added that with plants that are modified by cultivation (and recent scientific research has shown that all plants are thus modified), each repeated negation of the negation improves the qualities of the plant.[3]

He also cited the life cycle of the butterfly, which pairs, lays eggs and dies; and then each egg after its various metamorphoses emerges, once again, as a butterfly.[4]

In his polemic against the critics who ridiculed the law of negation of the negation saying that 'oats do not grow according to Hegel', Plekhanov quoted the botanist Ph. van Tieghem who wrote that: 'Whatever be the form of the plant. . . it reproduces itself in the same way as it was born: by dissociation.'[5]

*

With dialectical insight, Tom Paine observed (c. 1794): 'The sublime and the ridiculous are aften so nearly related, that it is difficult to class them separately. One step above the sublime makes the ridiculous, and one step above the ridiculous makes the sublime again.'[6]

Tolstoy, who had a deep understanding of human relationships, has left us a delightful short story, *A Happy Married Life*, which illustrates the negation of the negation very graphically. The passions of the first period of love of a newly married couple transform themselves into misunderstanding and later hate. In turn, the hate turns into a new love based on gratitude, affection and understanding.

Freud was one of the first psychologists to point out that the development of the sexual life of man is diphasic. At about the end of the fifth year of childhood, sexuality undergoes a lull in what he called (after Wilhelm Fliess) the 'latency period'. With the onset of puberty psychological sex life re-emerges reinforced by physiological changes, in its normal adult form.[7]

Repetition of Form

Each negation of the negation apparently brings us back to our point of departure. There is thus a repetition of form.

Plekhanov commented: 'Every phenomenon developing to its conclusion, becomes transformed into its opposite; but as the new phenomenon, being opposite to the first, also is transformed in its

turn into its own opposite, the third phase of development bears a formal resemblance to the first.'[8]

The negation of the negation is, according to Lenin, 'A development that repeats, as it were, stages that have already been passed, but repeats them in a different way, on a higher basis ('the negation of the negation'), a development so to speak, that proceeds in spirals, not in a straight line. . .'[9]

This, Lenin noted, gives rise to 'the repetition, at a higher stage, of certain features, properties, etc., of the lower, and. . . the apparent return to the old. . .'[10]

*

Let us consider two examples from history:

The English Civil War (1642-1649) saw the smashing of the feudal power and the execution of Charles I. After the consolidation of bourgeois power in 1660, there was the 'Restoration': another Charles was brought back to the throne on the invitation of parliament. This was, however, only an apparent return to the old, the repetition at the higher, bourgeois, stage of state power of the monarchist features of the feudal. Charles II might have 'reigned', but it was Parliament that ruled. As the French Ambassador at the time observed to Louis XIV: 'This government has a monarchical appearance because there is a King. But at bottom it is very far from being a monarchy.'[11]

A similar development took place in France, which in 1789 witnessed the end of feudalism and Louis XVI. Napoleon Bonaparte crowned himself Emperor in 1804 and was a 'monarch' in the sense that he had the feudal trappings of a monarchy, a crown and a throne. In essence, however, he was the first bourgeois dictator of France, as Cromwell was of England.

A repetition of form should not blind us to the reality of the change of content.

Superficial commentators have sought to prove the identity of the state forms in Nazi Germany and Soviet Russia. They ignore the basic difference between a capitalist state in convulsion and a workers' state however degenerate. The destruction of democratic rights in the first instance was acutely symptomatic of the last phase of a society in its death throes; in the second it was a retrogressive phase in the post-revolutionary development of a then economically backward society encircled by imperialism.

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Chapter Ten

The Transition from Quantity to Quality and Quality to Quantity

The most graphic law of dialectics and perhaps the easiest to grasp is the law of Transition from Quantity to Quality. It was also probably the first to be recognized.

Hegel acknowledged: 'The ancients were aware of the connection by which a change appearing as merely quantitative turns into one which is qualitative.'[1]

Let us, in passing, remind ourselves of the ancient fable: single rods can be easily broken, not so a faggot. As Aesop has told us, there is strength in numbers.

Anaximenes of Miletus, in the 6th Century B.C., with his theory of condensation and rarefaction, propounded the idea that qualitative changes lead to quantitative ones.[2]

Euripedes (480-406 B.C.) in his *Medea* declared: 'When love is temperate, nothing is more enchanting; but save me from the other sort!'

Terence (185-159 B.C.) in his *Eunuchus* pointed out that 'Rigorous law is often rigorous injustice.'

Ovid (45 B.C.-17 A.D.) in his *Metamorphoses* observed: 'Plenty makes me poor!'

In *The Merchant of Venice* we have: 'They are as sick that surfeit with too much, as they that starve with nothing,' (I, ii); and in *Romeo and Juliet*: 'Too swift arrives as tardy as too slow.' (II, vi).

Cervantes made Sancho Panza observe: 'Many littles make a much!'*

Engels has cited Napoleon Bonaparte: 'Two Mamelukes were undoubtedly more than a match for three Frenchmen; 100 Mamelukes were equal to 100 Frenchmen; 300 Frenchmen could generally beat 300 Mamelukes, and 1000 Frenchmen invariably beat 1500 Mamelukes.'[4]

A short story attributed to Tolstoy, *Three Rolls and a Cookie*, is often cited in illustration of this law. It concerns a man who sought to satisfy his hunger – three rolls did not suffice; but when he added a cookie and felt satisfied, he regretted that he had not eaten a cookie to start with and had spent money on the rolls.

The Unity of Quantity and Quality

Let us note the unity of quantity and quality, the fact that they are inseparably inter-related. Whenever we speak of concrete things, we have to specify them in terms of quantity as well as quality. We do not shop for sugar or anything else without specifying the quantity, nor do we merely ask for yards without stating whether we want cloth or barbed wire.

In his *Encyclopaedia*, Hegel stated: 'Quality determines quantity and quantity determines quality. This is a mutual, unsettled, dynamic *fluctuation* and unrest.'[5]

'In measure,' he wrote: 'Quality and Quantity are united.'[6]

James Clerk Maxwell, in his address to the British Association in 1870, said: 'it was a great step in science when men became convinced that, in order to understand the nature of things, they must begin by asking, not whether a thing is good or bad, noxious or beneficial, but of what kind it is, and how much there is of it? Quality and Quantity were then first recognized as the primary features to be observed in scientific inquiry.'[7]

Limits

In practice, and even in theory (mathematics), no process can be carried on indefinitely. There are definite limits, 'nodes' as Hegel

* A little too much generally ends in a hangover. As Engels pointed out, the 'morning after' feeling is quantity transformed into quality.[3]

called them, beyond which the process becomes impossible or gives rise to new phenomena.

Every child knows that there is a limit to the size to which a balloon can be blown, that there is a critical point beyond which quantity passes into quality, and the balloon ceases to increase in size and bursts; what is left is no longer a balloon, but a shred of rubber.

Trotsky pointed out that every cook knows that the quantity of salt affects the quality of food: insufficiency makes food insipid, excess renders it unpalatable.[8]

There is a recognition of the working of this law in the old saying about the straw that broke the camel's back, and in the abbreviated reference in English idiom to the 'breaking point' as the 'last straw'. The point of exasperation is 'the limit'.*

Freud once related the sad folk-tale of a village work-horse which was weaned from the habit of eating oats by the gradual reduction of its daily ration to – nothing.[9]

The Formulation of the Law

In *Capital*, Marx gave credit for the formulation of the law to Hegel.[10] Engels noted that the formulation was 'an act of historical importance.'[11]

In his *Logic* Hegel wrote:The ordinary notion of appearance or disappearance of anything is the notion of gradual appearance or disappearance. Nevertheless, there are transformations of being which are not only changes from one quantity to another but also changes from the quantitative to the qualitative.[13]

In his *Encyclopaedia:* 'To the extent that quality and quantity are still differentiated and are not altogether identical, these two definitions are to some degree independent of each other, so that, on the one hand, the quantity may change without the quality of the object changing, but on the other, its increase or decrease, to which the object is at first indifferent, has a *limit* beyond which the quality changes. Thus, for example, alterations in the temperature of water at first do not affect its liquid state, but if the temperature is further increased or decreased, there comes a point when this state of cohesion undergoes a qualitative change and the water is transformed

* W.L. Ferrar, the author of some excellent textbooks of mathematics has warned us that we should not, in mathematical studies, reach 'the point of boredom'.[12]

into steam or ice. It seems at first that the quantitative change has no effect whatsoever on the essential nature of the object, but there is something else behind it, and this apparently simple change of quantity has the effect of changing the quality.'[14]

Hegel again: '. . . A little less, a little more constitutes that limit beyond which frivolity ceases and there appears something quite different, crime; whereby right passes over into wrong, and virtue into vice.'[15]

Freud explicitly accepted the operation of the law of Quantity into Quality in psychology.*[16] For example, he pointed out: 'A surplus of sexual aggressiveness will change a lover into a sexual murderer, while a sharp diminution in the aggressive factor will lead to shyness or impotence.'[17]

Temperature and Pressure

Life, as we know it, can exist only within definite limits of temperature and pressure.

Even within these limits, at extreme conditions, phenomena become distorted.

Jack London has left us a powerful short story (*To Light a Fire*) describing the uncanny world of –50 degrees Centigrade.

J.B.S. Haldane has provided us with very convincing experimental evidence of the change in physiological reactions at high and low pressures. (He was, incidentally, his own guinea pig in the experiments.) Under extreme conditions, normal physiological phenomena not only become exaggerated, but also give way to completely different ones.[18]

Even before the work of Haldane we knew that the lower limit for diving without pressurized suits is about 120 feet, and that for pressurized suits is about 300 feet. Below that we need armourized diving bells.

Absolute Temperature

The limits we have so far come across have been from daily life.

There are also natural limits. Let us, following Maxwell's advice, 'interrogate Nature herself.'[19]

* In fairness to Freud we must say that he was not an admitted dialectician. For his views on Hegel and Marx see Lecture XXXV in *New Introductory Lectures* (1930).

In 1854, Lord Kelvin by an inspired process of extrapolation, concluded that there is a natural lower limit to temperature, 'the absolute zero', (–273 degrees Centigrade). The new scale of temperature was, appropriately, termed the Kelvin scale. We now know that this limit can be approached but not reached.

'Critical Points', 'Thresholds' and more 'Limits'

Quite early in history mankind came across critical points (Hegel's 'nodes', Maxwell's 'singular points'): the boiling point and the freezing point of water, the melting points of metals, the points of ignition of various materials, etc., although the philosophical significance of the phenomena was realized very much later.

★

The human ear is sensitive over a wide range of frequencies, but it does not respond to 'infra-sonic' vibrations (less than 17-20 per second). Some fish do, and that, we are told, is how they get advance warning of brewing storms. Again, the human ear does not register 'ultra-sonic' vibrations (more than 20,000 per second), which can be 'heard' by some insects, dogs, bats, whales and dolphins. 'Ultra-sonic' waves have various uses, for example in cleaning, cutting and the destruction of insect pests.

It is now common knowledge that 'the sound barrier' (Mach I, i.e., 1000 feet per second), once thought to be an insuperable limit to air speeds, is a critical point at which we have the sonic boom, and other phenomena beyond.

Critical points are sometimes described in science as 'thresholds'. . .

There is the 'threshold of audibility': only sounds of sufficient intensity can be heard by the human ear; and the 'threshold of feeling', when the intensity is so great as to cause a painful sensation.

In optics we have the well-known phenomenon of the 'Critical angle'*, beyond which light rays emerging from a denser medium into a rarer are totally internally reflected. From the fish-eye point of view, the poor fish can see the bait but not the angler.**

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* Johannes Kepler: *Dioptrice*, Vienna, 1611. (See A.S. Ramsey: *Elementary Geometrical Optics*, Bell, 1914.)

**There is a beautiful photograph of the phenomenon in A.E.E. Mackenzie: *Light*, Cambridge, 1939, p. 43.)

Diamond is not only the hardest natural substance, it also has the lowest critical angle (24 geometrical degrees compared to 34 to 40 degrees for the various glasses). Light is therefore many times totally internally reflected within a diamond to give it its characteristic sparkle.

From primitive times, mankind must have wondered at the rainbow. It was only in the 17th century that Rene Descartes gave the explanation of the phenomenon. Incidentally, there is a 'critical angle' also for rainbows, which cannot be formed once the sun is more than 41 degrees above the horizon.

It required the genius of Sir Isaac Newton to show that the optical spectrum is the result of the break-up of white light into its constituent colours. Till his work it was thought – and taught – that white light was 'pure' and that the colours were 'impurities'.*

In 1800, Sir William Herschel, using the thermometer, extended our knowledge of the spectrum into the invisible 'infra-red' region and showed that heat and light are similar phenomena. The next year, Professor Ritter of Jena extended the visible spectrum at the other end into the ultra-violet.

James Clerk Maxwell proved theoretically in 1864 that the visible spectrum and its extensions were only a small part of the electro-magnetic spectrum. Experimental proof came with Hertz's discovery of 'wireless' waves in 1888 and Roentgen's discovery of 'X-rays' in 1895. High frequency 'gamma-rays' were added after the study of radio-activity in 1896.

The electromagnetic spectrum is a dynamic illustration of the law of Transition from Quantity into Quality: with a change of quantity, an increase in the frequency of the waves, or, what is the same, with the decrease in wave length, the quality of the radiation changes, from wireless waves, through heat (or infra-red), light, through its variegation from the red to violet, ultra-violet, 'X' and 'gamma' rays.

*

D.I. Mendeleyev found (1860) two critical points: critical pressure below which cooling alone cannot liquefy gases, and critical temperature above which pressure alone cannot liquefy gases.

Independently, Thomas Andrews in Scotland discovered the same phenomena (1863).

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* This notion persists in our superstitions.

After Pierre Curie, we have the 'Curie point', that critical temperature above which ferro-magnetic materials lose their permanent magnetism. (For Iron, c. 770 degrees Centigrade).

A law of photoelectricity states that every substance has its 'threshold frequency' below which photoelectric phenomena cannot be observed.

*

In these days of rocketry, every schoolchild knows that there is what is termed the 'orbital velocity', the necessary minimum speed to place a rocket in orbit (7·93 km/sec.). If the velocity exceeds the 'escape velocity' (11·2 km/sec.) the rocket travels into outer space.

We mention, without discussion, some other limits.

Nuclear physics has its 'critical mass', 'critical volume', etc.

Einstein has proved for us that the maximum velocity for a material particle or a signal can never exceed *c*, the velocity of light (186,000 miles/sec., or 300,000 km/sec.).

There is the 'Roche limit': if a satellite, before solidifying comes within a distance of two and a half times the radius of the mother planet, it breaks up.[20]

The Indian astro-physicist S. Chandrasekar, has proved that the range of the masses of the stars is one-eighth to twenty times the solar mass. A body a fiftieth of the solar mass will not be luminous. Jupiter has a mass below the critical mass and, as Gamow described it, is 'the largest stone' in the solar system, shining, like the other planets only by reflected light.[21]

There is also an upper limit to the mass of the stars: one with a hundred times the solar mass will be unstable.[22] Upper limits, we are told, apply also to galaxies.

Quantity and Quality in the Atomic World

Chemistry provided both Hegel and the Marxists with numerous illustrations of this law.[23]

Marx noted: 'The molecular theory of modern chemistry. . . rests on no other foundation.'[24]

Engels observed: 'Chemistry can be termed the science of qualitative changes of bodies as a result of changed quantitative composition.'[25]

The number of atoms of oxygen that unite with an atom of

carbon determines the properties (the 'qualities') of the compound. Carbon dioxide (CO_2) is vital and plays a fundamental role in the life cycle of animals and plants; carbon monoxide (CO) is fatal. Hydrogen peroxide (H_2O_2) has properties different from water (H_2O).

A penetrating odour near a working electrostatic machine made Martin van Marum suspect (1785) the existence of a new substance which Schonbein (1839) named 'ozone' (from the Greek for odour). In 1886 J. Soret found it to be a triatomic allotrope (O_3) of oxygen which exists far more abundantly in the ordinary diatomic form (O_2). In 1910 chemists came across oxozone (O_4).

Oxygen is vital to all forms of life (Humphrey Davy, 1797), while ozone has the distinctive property of absorbing ultra-violet rays which, beyond limits, are fatal to living things.

Many other elements exist in allotropic forms. A well-known example is carbon which exists in two other forms, physically different but chemically identical: graphite and diamond. Among other examples are sulphur, phosphorus and tin.

A major factor that led to the death of the Antarctic explorer Scott in 1912 was the fact that of the ten allotropes of tin, the one used as solder on his fuel cans disintegrates into a powder at –43 degrees centigrade. In Antarctic conditions, the solder proved worthless and Scott and his party perished in the snow.

*

In organic chemistry there are general formulae for 'homologous series.'

For example, the paraffins can be described by the formula C_nH_{2n+2}. For $n = 1$, we have methane, for $n = 2$, ethane, and so on. Moreover for small n we have gases, for medium n, liquids, and for large n, solids (in this case, waxes).

Again, the alcohols have the general formula $C_nH_{2n+1}OH$. For $n = 1$, we have CH_3OH, methyl alcohol which has important industrial uses but is injurious to health. For $n = 2$, we have C_2H_5OH, ethyl alcohol, which is intoxicating.

A.M. Butlerov, unsung Russian scientist and one of the founders of organic chemistry, extended (1861) the idea of general chemical formulae (J.J. Berzelius, 1814) to structural formulae. Different atomic arrangements within the molecule, different 'spatial

groupings', the importance of which, as we shall see, Engels noted, give rise to 'isomers', compounds with the same general, but different structural formulae, and widely different in chemical properties. An example is the general formula C_2H_6O which can stand for dimethyl ether, a gas, or ethanol, a liquid.

It is a well-known fact that the maximum number of regular ('platonic') solids is five.

The earliest of many outstanding discoveries of Louis Pasteur was the detection in 1848 of 'right-handed' and 'left-handed' crystals, which, while not asymmetrical, were mirror symmetrical and had different (optical) properties.

We mention the limit to molecular arrangements in crystalline chemical compounds. In 1881, E.D. von Fedorov, of Russia, showed that there can be only 230 types of crystals in nature. His assertion was later borne out by the X-ray analysis of crystals by von Laue (1912) and the Braggs (Sir William and his son, Lawrence).[26]

The Mendeleyev Classification of the Elements

On the 17th of November 1869, Dmitry Ivanovich Mendeleyev of the University of St. Petersburg published his tabulation of the then known sixty four chemical elements according to their 'atomic weights'. He gave each of them an ordinal number, now symbolized *Z*.

He showed that when thus arranged, the chemical properties of the elements changed with an increase of 'atomic weights', and were *periodically repetitive*.

What was more, in 1871, he *predicted* the existence *and the properties* of 'missing elements'.

His predictions were soon confirmed. In 1875 Lecoq de Boisbadran isolated gallium ($Z = 31$); in 1879, L.F. Nilson detected scandium ($Z = 21$); and in 1886, C. Winkler discovered germanium ($Z = 32$).*

Experimental studies showed that Mendeleyev's theoretical predictions of their chemical properties were startlingly accurate. Of the 37 elements since discovered, Mendeleyev predicted the existence of 21![27]

Mendeleyev was fortunate enough to live long enough (till January 1907) to see the addition by William Ramsay of the inert

gases as 'Group 0' of the periodic table, the discovery of polonium* ($Z = 84$) and radium ($Z = 88$) by Pierre and Marie Curie (1898) and actinium ($Z = 89$) by Andre Debierne. (1899).

In his *Foundations of Chemistry* (1869-1871), which has been described as 'a masterly systematization of extant chemical knowledge', Mendeleyev ventured to say: '. . . the atoms of simple bodies are complicated substances, formed by the combination of a number of *still more minute particles*. . .'[28] (Our italics).

*

Engels, evidently, had no first-hand knowledge of Mendeleyev's work. (The bibliography of *Dialectics of Nature* (1879) has no mention of it. He probably learnt of its contents from his Manchester friend, the chemist K. Schorlemmer.)

In 1879 he wrote, enthusiastically: 'By means of the – unconscious – application of Hegel's law of transformation of quality into quantity, Mendeleyev achieved a feat which it is not too bold to put on par with that of Leverrier in calculating the orbit of the then unknown planet Neptune.[29]

Engels, too, conjectured: 'If all differences and changes are to be reduced to qualitative differences and changes, to mechanical displacement, then we inevitably arrive at the proposition that all matter consists of *identical*, smallest particles, and that all qualitative differences of the chemical elements of matter are caused by qualitative differences in *number* and by the *spatial grouping* of those smallest particles to form atoms. But we have not got so far yet. . .'[30]

In these remarkable lines, writen in 1885, Engels was already visualizing 'smallest particles' and their spatial grouping. With his spatial grouping, Engels the philosopher was ahead of Mendeleyev the chemist.

*

Engels closed his notebooks on science in 1886. He had to edit the unfinished manuscripts of Marx.

*

On the 8th of November 1895, three months after Engels died, Wilhelm Conrad Roentgen of the University of Wurzburg

* Each scientist named the new element after his native land; Madame Curie hailed from Poland.

accidentally discovered a hitherto unknown radiation which he called 'X-rays'. These penetrating rays not only helped in medical diagnosis but also played a vital role in unravelling the mysteries of the atomic world.

As we have already seen, discoveries followed in rapid succession.

Also accidentally, in 1896, Henri Becquerel discovered another radiation which Marie Curie named (1898) 'radio-activity', insisting from the beginning, with the intuition of genius, that the phenomenon was atomic in origin.

In 1902, Rutherford and Soddy put forward the revolutionary idea that radio-activity is the spontaneous self-transformation of the radio-active elements.

Spatial grouping played an important part in the new atomic model of Rutherford and Bohr (1913). The electrons could only occupy permitted orbits or 'shells' (Bohr's 'rings') in permitted numerical combinations.

Also in 1913, the British physicist H.G.J. Moseley, after X-raying the atoms in a series of brilliant experiments, found the physical significance of ordinal number Z: it is equal to the positive nuclear charge, or, what amounts to the same thing, (as the atom is electrically neutral), the number of electrons in orbit.

Atomic properties (qualities) change with each integral change in Z, from hydrogen ($Z = 1$) to uranium ($Z = 92$), the heaviest natural atom.*

*

In 1912 Frederick Soddy announced the existence of 'isotopes' (as Bohr had suspected a year previously), atoms with different masses but with identical chemical properties and therefore occupying the same place (*isos topos*, in Greek) in the periodic table.

F.W. Aston confirmed Soddy's theory by fundamental experiments with his 'mass spectrograph' in 1918.

The explanation of this phenomenon came with the discovery of another fundamental particle, with the mass of proton, but without an electrical charge, the existence of which had been predicted by Rutherford in 1920. This particle had turned up in the experiments

* For the record, some elements have not yet been found in nature, but have been made artificially: technetium ($Z = 43$) in 1937, promethium ($Z = 61$) in 1947, astatine ($Z = 85$) in 1940, and francium ($Z = 87$) in 1939.[31]

of Frederick Joliot and Irene Joliot-Curie, and those of Boethe and Becker. It was identified by James Chadwick in England (1932) and named the 'neutron'.

Physicists have now accumulated an impressive – and rather bewildering – array of 'elementary particles' and created more complex concepts of atomic structure.

Let us, for our present purposes, be satisfied with electrons, protons and neutrons, with which we can build what has been happily called the '1932 model' of the atom[32] – it is adequate for our survey.

The number and spatial grouping of the orbital electrons determine the combining power or 'valency' (Frankland, 1833) of the atoms, and thus their chemical properties.

The mass of electrons is negligible, atomic mass comes from the nucleons — protons and neutrons.

While the number of protons in the nucleus of any given atom must always equal Z, the number of neutrons can vary within small integral limits and these variations give rise to the isotopes.

In 1931, H.C. Urey isolated 'heavy' hydrogen, now called deuterium, with a neutron in the nucleus (which the normal hydrogen has not). Later, scientists discovered tritium, another isotope of hydrogen with two neutrons in the nucleus.*

'Heavy water' (D_2O) in which deuterium combines with oxygen, arrests growth and kills some small forms of life.

The number of neutrons determines the stability of the nucleus. The *last* stable nucleus is that of bismuth ($Z = 83$). From polonium ($Z = 84$) onward the nuclei are radioactive, that is, inherently unstable, and go through self-transformation, often through a series of self-transformations, to a stable form.

In *The Interpretation of the Atom** (1932), Frederick Soddy compared the scientists who studied radioactivity to astronomers; they could only observe, not experiment.

While it is still true that radioactivity cannot be speeded up, retarded or stopped, barely two years after Soddy's observation

* In 1913, Neils Bohr in the presence of many distinguished scientists including M Curie and Rutherford, claimed that his 'X-3' was hydrogen with a thrice heavy nucleus. He was challenged by J.J. Thomson who maintained that this was only a triatomic molecule. Years later 'X-3' proved to be tritium.[33]

* John Murray, publishers.

Frederick Joliot and Irene Joliot-Curie created artificial radioactivity. We now have radioactive isotopes: radio-nitrogen, radio-aluminium, radio-iodine, etc. In every case it was found that the instability was due to the number of neutrons in the nucleus.

Neutrons also provided new and more effective missiles with which to bombard the nucleus.

In the expert hands of Enrico Fermi, beginning with 1934, neutron bombardment produced new atomic miracles.

In 1940, Fermi created neptunium ($Z = 93$), the first artificial, 'trans-uranic', element. Others, also unstable, soon followed, among them fermium ($Z = 100$) and mendeleyevium ($Z = 101$). The score a few years ago stood at 105.

Yet, there is an upper limit to Z. Ya.I. Frenkel, Bohr and Wheeler have shown that fission must follow the creation of trans-uranic elements.

Fermi and his team worked the first atomic 'pile' on 2nd December 1942. The rest is history, Hiroshima and Nagasaki.

*

Even before some of these exicting discoveries, at the Mendeleyev Congress in 1925, Trotsky claimed: 'In Mendeleyev's Periodic Law, in the chemistry of radioactive elements, the dialectic celebrates its own more outstanding victory.'[34]

The next year Trotsky made a prediction of the future use of atomic energy.[35] A biographer, Isaac Deutscher, has commented that Trotsky was the first politician to refer to atomic energy at a time when even scientists dared not dream of the many discoveries and achievements to come.

Quantity and Quality in the World of Biology

Biology is a source of some graphic illustrations of this law. Let us begin with a few homely examples.

Darwin in his *The Formation of Vegetable Mould Through the Action of Worms* (1881) showed how small causes acting for a long time produced great results.[36]

Darwin also gave the example of short-billed pigeons: when beaks get too short the chicks cannot break through their shells by

their own efforts and have to be helped to hatch out by the breeder himself.*[37]

In his Mendeleyev commemoration lecture (1925) Trotsky said of Darwin: 'This highly gifted biologist demonstrated how an accumulation of small quantitative variations produced an entirely new biologic quality . . .'[39]

The Fertility of Animals and Plants

Hyman Levy gave the simple instance of a pair of rabbits taken to Australia at the end of the 18th Century as pets multiplying so much that the offspring have become pests.**[40]

There are many other examples of the runaway population explosion of non-endemic species: the American grey squirrel in England[41], the Indian mongoose in Jamaica and sparrows in California.[42].

While such examples may be explained by ecological imbalance, the fact is that, as Darwin observed: 'There is no exception to the rule that every organic being naturally increases at so high a rate that, if not destroyed, the earth would soon be covered by the progeny of a single pair.'[43]

As early as 1740 Carl Linnaeus pointed out in *De Tellure* that an annual plant would, in the twenty years, have a million offspring.[44]

A six-foot female cod lays about six million eggs which hatch out in twenty days. Ling, another six-foot fish, lays some twenty million.[45]

As to quick-breeding house-flies, the theoretical results are horrifying. Each couple will have 20,000 offspring each month.[46]

Yet there are many factors that hold the growth of population of species in check, so that under normal circumstances, the numbers are maintained more or less constant.

This basic fact is one of the corner-stones of Darwin's theory of evolution. As D'Arcy W. Thompson has observed: 'But multiply as they will, these vast populations have their limits. They reach the end of their tether, the pace slows down, and at last they increase no more. Their world is fully peopled, whether it be an island with its

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* Trotsky, in an interesting aside, compared the British Fabians to short-billed pigeons.[38]

**The late Arthur Upfield has left us a vivid description of the problem in one of his novels.

swarm of humming-birds, a test-tube with its myriads of yeast-cells, or a continent with its millions of mankind. Growth, whether of a population or an individual draws to its natural end. . .'[47]

Malthus' Theory of Over-Population

In 1789 there appeared in England a book by Rev. T.R. Malthus entitled *Essay on the Principle of Population*, the central proposition of which was: 'Population when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio.* A slight acquaintance with numbers will show the immensity of the first power in comparison with the second.'[48]**

The reverend's acquaintance with numbers was, as admitted very slight. The law of growth of human population is not the simple law of geometric progression, nor is the growth of subsistence arithmetical progression.

Malthus had, perhaps, good reason for his alarm. The rate of growth of population in England was constant till 1750. With the Industrial Revolution came a population boom, the rate of growth increased, and the population which was 6,500,000 in 1750 rose to 16,300,000 in 1801.[49] Still even these figures do not support Malthus' contention that population in general would double itself every twenty five years.

The important aspect of the matter was not the parson's misunderstood arithmetic. His argument was politically motivated. He provided a pseudo-scientific argument for the reactionaries of his time, and also ours.

Marx observed that Malthus' arguments were directed 'against the French Revolution and the contemporary ideas of reform in England (Godwin, etc.)'[50]

While granting that Malthus' theory provided a 'stimulus', Marx exposed him as a 'plagiarist', a 'bought advocate' responsible for 'a libel on the human race.'[51]

Marx pointed out that the theory is anthropocentric and also

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* An increasing geometric series is multiplicative: e.g.: 2,4,8,16,32. . . An increasing arithmetic series is additive: e.g.: 2,4,6,8,10. . . As can be easily seen the rate of growth of the former far exceeds that of the latter.

**R.L. Meek has made a comprehensive compilation of the views of *Marx and Engels on Malthus*. (Lawrence and Wishart, 1953)

misanthropic: why single out human beings for fertility and proliferation?[52]

Marx emphasized that there is no abstract law of human population: 'every stage of development has its own law of population. . .'[53]

Engels noted: '. . . the pressure of the population is not upon the means of subsistence but upon the means of *employment*; mankind could multiply more rapidly than bourgeois society can demand. To us a further reason for declaring this bourgeois society a barrier to development which must fall. . .'[54]

*

Charles Darwin happened to read Malthus in October 1838. After some years of careful thought, he drew a theoretical conclusion from the mass of material he had collected: there is a survival of the fittest in the struggle for existence.[55]

It must be noted, however, as Marx did, that while Malthus singled out man for proliferation, Darwin recognized that the phenomenon applied, theoretically, to *all* animals and plants.[56]

This, incidentally, is a classic example of an erroneous idea sparking off a profound theory.

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D.I. Mendeleyev dismissed the theory of over-population as 'Malthusian gibberish.'[57] 'The more the merrier!'* he is said to have declared, citing facts and figures to prove that, *theoretically* at least, there was ample room for expansion of productive forces to support an increasing population of Russia.[58]

In *On Growth and Form*,** (Chapter III), D'Arcy Wentworth Thompson discusses the rate of growth of population and, while admitting that Malthus posed an important problem, dismisses the theory as based on 'very slender' evidence.

We have seen Thompson's observation that growth is not without its limits, that it has its 'natural end'.[47]

Quetelet implied and Verhulst clearly stated that there is a

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* Dmitri Ivanovich was the youngest of seventeen children.

**This is a monumental work. Many years in the writing (1916-1941), it is a masterly application of mathematics to the study of Nature. It also happens to reach the heights of literature. (It is to be hoped that the Cambridge University Press will publish a new edition with all the multi-lingual quotations put into English.)

built-in retardation factor proportional to the growth factor.

In 1838, Verhulst used the S-shaped 'logistic' curve of Edward Wright (1599) to describe the growth of population. This curve grows from an asymptotic minimum to an ill-defined asymptotic maximum.

That this dialectical thinking was also scientifically correct is proved by the fact that the predictions based on it proved accurate: Verhulst in his time predicted that the limit of the population of France would be about 40 million and that of Belgium about 8 million. The figures turned out to be true a century later.[59]

Impossible Worlds*

Being accustomed to visual perspective from infancy, we readily accept the concept of geometrical 'similarity': objects farther away, toys, miniatures, drawings, photographs and maps have reduced linear dimensions. By extension, we accept the geometrical 'similarity' in enlargements, large-scale paintings, sculptures and the projections of the cinema.

As D'Arcy W. Thompson has observed, we accept the proportions of the real world from whichever end of our binoculars we view it.[60]

Geometrical reductions and enlargements are termed, in mathematics, 'homothetic transformations'.

It was Galileo who was the first to realize and point out, in one of his *Discorsi* (1638), the impossibility of a physical similarity corresponding to the geometrical. He introduced the concept of 'similitude' or 'dynamical similarity'.

He began from an elementary arithmetical fact known at least from the time of Archimedes: when a linear dimension is doubled, the surface area is quadrupled and the volume increases eight times.**

This elementary consideration is of great importance in science.

It is the basis of the theory of measurement, of the theory of units and 'dimensions'. It features in the study of models in hydraulics, ship and aeroplane construction.[61]

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* With apologies to the late J.B.S. Haldane who has left us an entertaining essay on this topic: *Possible Worlds*.

**For example, if the sides of a unit cube are doubled, the area of each face will become 2×2, that is four square units, and the volume becomes $2 \times 2 \times 2$, that is 8 cubic units.

As Thompson has pointed out, it should have been used, after Galileo and Borelli, in the study of nature, but unfortunately was not.

Let us follow, for a while, the trend of thought in Chapter II ('On Magnitude') of Thompson's classic.

Jonathan Swift's Lilliputians were aware of geometrical similarity. Gulliver being twelve times their linear dimensions, they allowed him 1728 (i.e., 12 x 12 x 12) times their own quota of food and wine.

Swift, Thompson observes, was unaware of Galileo's Principle of Similitude.

Else, he would not have written:

So, Nat'ralists observe, a Flea
Hath smaller Fleas that on him prey.
And these have smaller Fleas to bite 'em.
And so on ad infinitum.
(*On Poetry*, 1833)

Lilliputians, Brobdignagians and Swift's infinite series of fleas are physically impossible creations of the artist's imagination. So also are *Tom Thumb* of the Brothers Grimm and Lewis Carroll's *Alice* who grows or shrinks acording to the 'Eat me!' or 'Drink me!' formulae.

Homothetic transformations do not occur in Nature. Scale imposes limitations on, and is a determining factor of, form.

Long before the discovery of the Californian Sequoia and the Pines of British Columbia, Galileo sagaciously suggested, as it turned out, accurately, that the maximum height of a tree could be about 300 feet.* Jack's Bean-Stalk can exist only as a fairy tale fantasy.

Carl Bergman showed why (and this is called his 'law') the mouse is the smallest possible land animal and that there are no small animals in the sea. Warm-blooded whale calves, born in the cold sea, have to be about 25 feet long and weigh about 20 tons. For the same reason, there are no small animals or birds in the Arctic and Antarctic.

Only insects and small birds are capable of stationary or hovering flight. Even if ostriches were equipped with large wings, their minimum speed for take-off would have to be about 100 m.p.h. and they would, as with large aeroplanes, require a long run-way, not provided by Nature.

Body weight increases as the cube of, and the cross-section of

* In the units of his time. The tallest known tree is a Sequoia of 368 feet.[62]

the bones only as the square of the increase in the linear dimension. J.B.S. Haldane pointed out that our fairy tale giants could not take a step without cracking their bones. For the same reason, elephants, rhinoceros and hippopotamus have, of necessity, stocky legs, while giraffes have small bodies.

The dinosaurs, whose shape and size were adapted for swamp life, became creatures of the past when the swamps dried up.[63]*

At the other end of the biologic scale, an insect cannot afford to get wet. A thin film of water will have a weight out of proportion to the weight of the poor insect.

Insects must, of necessity, have multiple or 'compound' eyes in order to allow for the effects of 'diffraction' (the blurring of images when light passes through very small apertures or past sharp edges.) As a result, the proverbial 'bee-line' is not a straight line but the arc of an equiangular spiral.[64]

Montage

Some aspects of the Law of Transition from Quantity to Quality were not only implicitly understood but also explicitly used by some ancient people.

Two Chinese pictograms give rise to an ideogram. For example, Tree + Tree = Forest.[65]

In Egyptian hieroglyphs: Eye + Water = Tears.

The hieroglyph for one million was, appropriately, an astonished person.

All children are taught to count on their fingers.** (It is not accidental that the word digit stands for finger, toe, or numeral). Some genius in pre-Roman times counted one, (I), two (II), three (III), four (IIII), *hand*, and the notation for five was the ideograph of the hand – V. Roman numeration was decimal, notation quintal. The ideograph for ten was two hands: V + V = X.

In some primitive languages, the word for ten is two hands, or sometimes, by extension, *man*.[67]

Sergei Eisenstein, the great film-director, based his theory of

* Just as the discovery of coal in the Antarctic (Admiral Byrd, 1929) indicates that there were carboniferous forests in that area in past ages, the existence of dinosaur eggs in the Mongolian desert indicates that that area was once a large swamp.

****Until taught to count on fingers, for children, as for many primitive people, any number after three is 'heap'.**

montage on the fact that a new quality emerges from the juxtaposition of two film sequences. This, he said, is true for any two facts, or objects, or phenomena, and quoted a tribute to the poet Browning who, 'out of three sounds' could 'frame, not a fourth sound, but a star.'[66]

Eisenstein gave credit to Lewis Carroll who was perhaps the first person to draw attention to the emergence of new qualities from the juxtaposition of two words in a 'portmanteau'.

In *Alice through the Looking Glass* (Chap. VI), Humpty Dumpty says: 'Well, *slithy*, means lithe and slimy. *Lithe* is the same as active. You see, it's like a portmanteau – there are two meanings packed up in one word.'[68]

With Eisenstein we draw attention to Freud's discovery of the fact that the portmanteau effect is also observed in psychological phenomena. In his study of dreams Freud came across 'condensation', the unconscious formation of 'fresh unities' out of separate thoughts.[69]

In *Wit and its Relation to the Unconscious*, Freud studies inter alia the 'Formation of Mixed Words'[70] and quotes Heine's 'famillionaire', Disraeli's 'anecdotage' and Brill's 'alcoholidays'.

Leaps

The transition from quantity to quality is not a gradual or continuous process.

Our child's balloon did not burst gradually.

Water boils all of a sudden, and just as suddenly does it turn into ice on cooling.

Hegel drew attention to the sudden changes in nature, the breaks in continuity and the leaps from one stage to another.

In his *Logic* he wrote:

> It is said that there are no leaps in nature; and ordinary imagination, when it has to conceive an arising or passing away, thinks it has conceived them. . . when it imagines them as a gradual emergence or disappearance. . .[71]

Changes in being consist not only in the fact that one quantity passes into another quantity, but also that quality passes into another quality and vice versa. Each transition of the latter kind represents an interruption in gradualness, and gives the phenomenon a new

aspect, qualitatively distinct from the previous one. Thus, water when it is cooled grows hard, not gradually . . . but all at once; having already been cooled to freezing point, it can remain a liquid only if it preserves a tranquil condition, and then the slightest shock is sufficient for it to become hard . . .'[72]

As Hegel pointed out, not only are the transitions from quantity to quality a general feature of natural processes, they are sudden changes, breaks in continuity, leaps from one state to another, nodes in the process of development and change.

He added: 'All birth and death, instead of being a continued graduality, are rather an interruption of this, and are the jump from quantitative into qualitative change . . .'[73]

Engels repeated the point: 'In spite of gradualness, the transition from one form of motion to another always remains a leap, a decisive change . . .' and added that this is true in all fields, celestial and terrestrial mechanics, physics and chemistry. 'Then within the sphere of life the leaps become even more infrequent and imperceptible.'[74]

Though imperceptible, Engels noted that 'Nature is composed entirely of leaps.'[75]

Plekhanov observed:

> Quantitative changes gradually accumulating, become in the end, qualitative changes. These transitions occur by leaps and cannot occur in any other manner.[76]
>
> Dialectics . . . knows full well that in nature and also in human thought and history leaps are *inevitable*. But it does not overlook the undeniable fact that the same *uninterrupted process* is at work in all the phases of change. It only endeavours to make clearer to itself the series of conditions under which gradual change must necessarily lead to a leap . . .[77]

At birth the new-born of most animals lose the comforts of the womb or egg. Their supply of air and sustenance ceases *suddenly*. They then go through *two* 'revolutions': they begin to breathe through their noses (or gills) and eat through their mouths.

Insects go through metamorphoses. In his polemic against Tikhomirov, which is a neat and entertaining essay on sudden changes in nature and history, Plekhanov cited the example of the butterfly. A caterpillar grows bigger day by day, but up to a point. Suddenly, it becomes a chrysalis and remains dormant for a time,

until, just as suddenly, it emerges in all its beauty as a butterfly.[78]

It may be argued, as Plekhanov expected,[79] that the difference between what is gradual and what is sudden is relative, depending on the choice of time scale, and that 'Nature makes no jumps'.* But it is easy to visualize that, even within a chosen time scale, there are accelerations and, also, retardations.

Thus far, we have listened to the philosophers. Engels made his observation in 1878, Plekhanov in 1889. Let us now hear the scientists.

Max Planck, who as we have seen, discovered the discontinuity of energy and put forward the 'quantum hypothesis', in 1900, wrote: 'Recent discoveries have shown that the proposition (that Nature makes no jumps) is not in agreement with the principles of thermodynamics, and, unless appearances are deceptive, the days of its validity are numbered. Nature certainly seems to move in jerks, indeed of a very queer kind. In any case, the quantum hypothesis has given rise to the idea that in nature changes occur which are not continuous but of an explosive nature.'[81]

In the field of cosmogony, Laplace's theory of stellar evolution has been modified by later investigations. James Jeans has observed that the shrinking of celestial bodies has not been gradual, but has been a 'contraction in spasms.'[82]

*

In 1864, Thomas Huxley observed that 'Darwin has unnecessarily hampered himself by adhering so strictly to his favourite 'Natura non facit saltum'. We greatly suspect that she does make considerable jumps in the way of variation now and then, and that these saltations give rise to some of the gaps in the series of known forms.'[83]

In 1902, the Dutch biologist de Vries discovered the occurrence of 'mutations', sudden changes in the hereditary nature of living organisms.

In 1906, Sir Jagadish Chandra Bose claimed that plant growth occurs in small, rhythmic pulsations.

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* This aphorism is often attributed to Aristotle, but is probably due to Leibnitz: 'Natura non facit saltus.'[80]

The law of the transition from quantity to quality and vice versa is thus seen to operate in all spheres of existence. No process can be endless; at certain stages transitions must occur, and we must not expect gradualness, but suddenness, leaps and discontinuity.

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Index